Acerca de este libro

Esta es una copia digital de un libro que, durante generaciones, se ha conservado en las estanterías de una biblioteca, hasta que Google ha decidido escanearlo como parte de un proyecto que pretende que sea posible descubrir en línea libros de todo el mundo.

Ha sobrevivido tantos años como para que los derechos de autor hayan expirado y el libro pase a ser de dominio público. El que un libro sea de dominio público significa que nunca ha estado protegido por derechos de autor, o bien que el período legal de estos derechos ya ha expirado. Es posible que una misma obra sea de dominio público en unos países y, sin embargo, no lo sea en otros. Los libros de dominio público son nuestras puertas hacia el pasado, suponen un patrimonio histórico, cultural y de conocimientos que, a menudo, resulta difícil de descubrir.

Todas las anotaciones, marcas y otras señales en los márgenes que estén presentes en el volumen original aparecerán también en este archivo como testimonio del largo viaje que el libro ha recorrido desde el editor hasta la biblioteca y, finalmente, hasta usted.

Normas de uso

Google se enorgullece de poder colaborar con distintas bibliotecas para digitalizar los materiales de dominio público a fin de hacerlos accesibles a todo el mundo. Los libros de dominio público son patrimonio de todos, nosotros somos sus humildes guardianes. No obstante, se trata de un trabajo caro. Por este motivo, y para poder ofrecer este recurso, hemos tomado medidas para evitar que se produzca un abuso por parte de terceros con fines comerciales, y hemos incluido restricciones técnicas sobre las solicitudes automatizadas.

Asimismo, le pedimos que:

+ *Haga un uso exclusivamente no comercial de estos archivos* Hemos diseñado la Búsqueda de libros de Google para el uso de particulares; como tal, le pedimos que utilice estos archivos con fines personales, y no comerciales.

+ *No envíe solicitudes automatizadas* Por favor, no envíe solicitudes automatizadas de ningún tipo al sistema de Google. Si está llevando a cabo una investigación sobre traducción automática, reconocimiento óptico de caracteres u otros campos para los que resulte útil disfrutar de acceso a una gran cantidad de texto, por favor, envíenos un mensaje. Fomentamos el uso de materiales de dominio público con estos propósitos y seguro que podremos ayudarle.

+ *Conserve la atribución* La filigrana de Google que verá en todos los archivos es fundamental para informar a los usuarios sobre este proyecto y ayudarles a encontrar materiales adicionales en la Búsqueda de libros de Google. Por favor, no la elimine.

+ *Manténgase siempre dentro de la legalidad* Sea cual sea el uso que haga de estos materiales, recuerde que es responsable de asegurarse de que todo lo que hace es legal. No dé por sentado que, por el hecho de que una obra se considere de dominio público para los usuarios de los Estados Unidos, lo será también para los usuarios de otros países. La legislación sobre derechos de autor varía de un país a otro, y no podemos facilitar información sobre si está permitido un uso específico de algún libro. Por favor, no suponga que la aparición de un libro en nuestro programa significa que se puede utilizar de igual manera en todo el mundo. La responsabilidad ante la infracción de los derechos de autor puede ser muy grave.

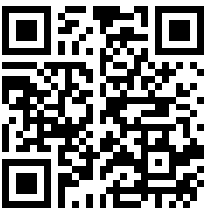
Acerca de la Búsqueda de libros de Google

El objetivo de Google consiste en organizar información procedente de todo el mundo y hacerla accesible y útil de forma universal. El programa de Búsqueda de libros de Google ayuda a los lectores a descubrir los libros de todo el mundo a la vez que ayuda a autores y editores a llegar a nuevas audiencias. Podrá realizar búsquedas en el texto completo de este libro en la web, en la página `http://books.google.com`

This is a reproduction of a library book that was digitized by Google as part of an ongoing effort to preserve the information in books and make it universally accessible.

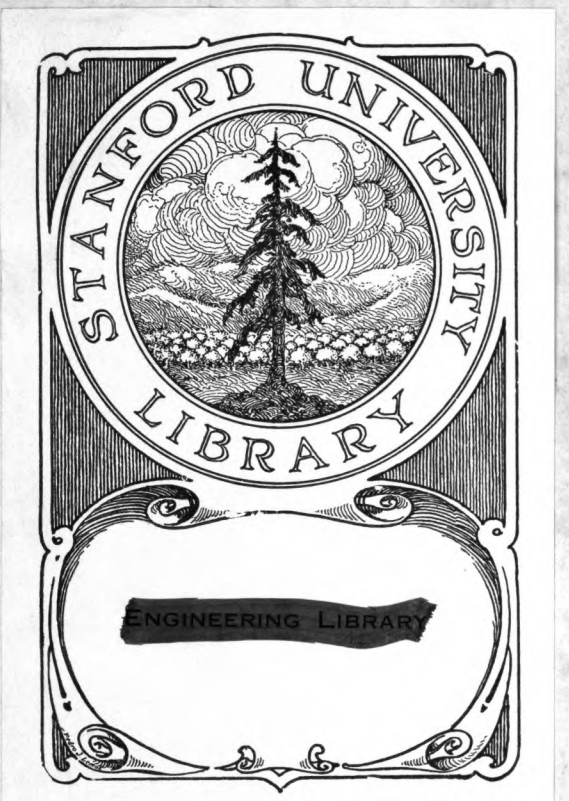
Google™ books

http://books.google.com

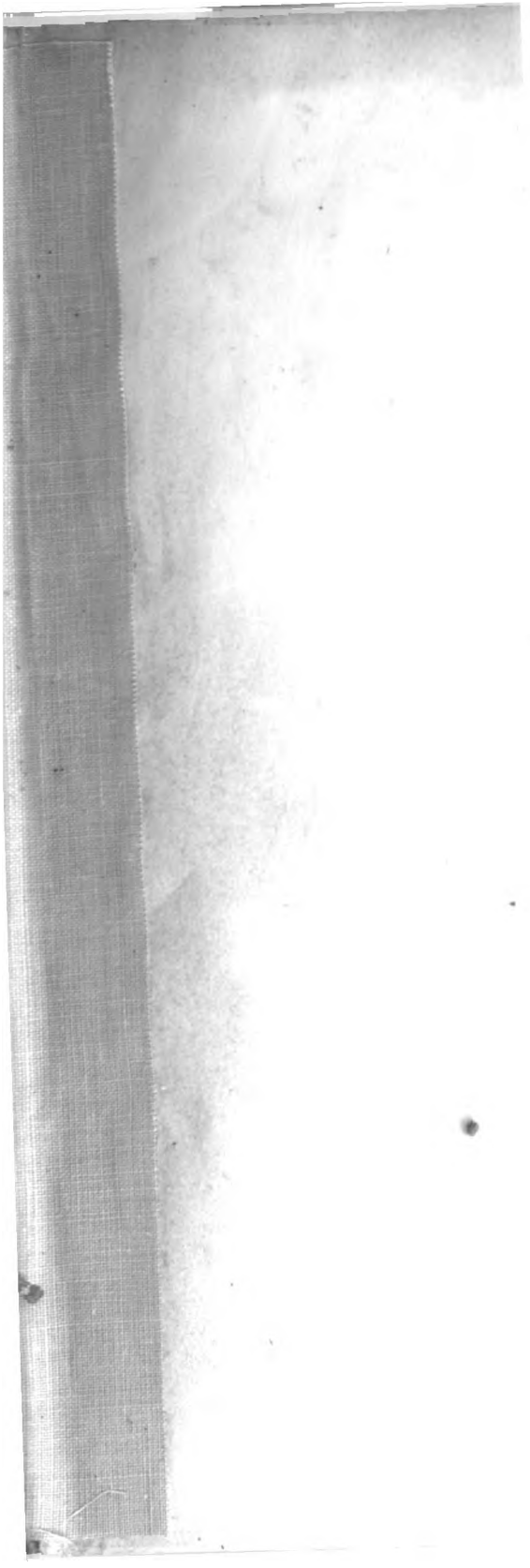


Stanford University Libraries
36105026498464

Digitized by Google



Digitized by Google



Digitized by Google

Digitized by Google

THE

ELECTRICAL MAGAZINE.

Digitized by Google

STANFORD LIBRARY
FEB
ENGINEERING

621.305
E 38 V5
v. 1

Digitized by Google

THE

ELECTRICAL MAGAZINE.

CONDUCTED BY

MR. CHARLES V. WALKER.

VOL. I.

LONDON:
PUBLISHED BY SIMPKIN, MARSHALL AND CO.
STATIONERS'-HALL COURT.
AND
H. BAILLIERE, 219, REGENT STREET.
PARIS: J. B. BAILLIERE, RUE DE L'ECOLE DE MEDICINE.
SOLD BY
G. KNIGHT & SONS, FOSTER LANE, CHEAPSIDE;
AND ALL BOOKSELLERS AND PHILOSOPHICAL INSTRUMENT MAKERS.

1845.

Digitized by Google

London :
Printed by Stewart and Murray,
Old Bailey.

Digitized by Google

PREFACE.

In presenting this First Volume of *The Electrical Magazine* to the Scientific Reader, and to the Public generally, we purposely avoid any preface of our own. We are rather desirous that it should speak its own Preface; we are desirous, that is, for our readers to pass their eye over the contents of the following pages, and compare them with the promises, which we made in our opening address. Our earnest endeavour has been to fulfil those our engagements to the very letter; and it has afforded us no small gratification to find that as month succeeded month, fresh and fresh treasures poured into our hands from every quarter; now from the smaller streamlets which lend their tributary aid to the ever flowing current; and ever and anon, from the very fountain heads themselves. It would be invidious in us to direct attention to the labours of some philosophers more than to those of others: let us rather view the volume as a whole, let us glance over its pages in due order, and we shall find that it is rich throughout with new discoveries and bright revelations. We hope that the progress of Electrical Science during these last two years has been faithfully followed, and that our *Magazine* may thus be regarded as a trustworthy chronicler. Of this we are quite sure, that our facilities for correct information are daily increasing;

Digitized by Google

and our readers shall command them all; and they may depend on our best endeavours to make each successive Number of the Electrical Magazine more and more worthy of their support.

It is believed that our plan of giving a perfect Index to the names, which occur throughout the volume, will afford great facilities for reference. In addition to this we give the ordinary analytic Index.

LONDON, *March* 31, 1845.

Digitized by Google

CONTENTS.

Page

Address to Readers . . . 1

1. Delineations produced by Electricity. G. Karsten . . . 5
2. Impressions or pictures by Electricity. G. Karsten . . . 8
3. Preparation of Carbon for Negative Plates. M. Bunsen . . 16
4. Battery on a new Construction. M. Bunsen 22
   Note on the above. Prof. De la Rive 24
5. Observations on Bunsen's Battery. M. Becquerel . . 25
6. On a new Voltaic Combination. Prof. De la Rive . . . 28
7. Theory of the Voltaic Condenser. Prof. De la Rive . . . 30
8. Observations on the Voltaic Condenser. M. Bouquillon . . 40
9. New means of producing Electric Pictures. M. A. Morren . . 41
10. Electricity from discharge of a Gun. Dr. F. Elice . . . 43
11. Animal Electricity. Prof. Ch. Matteucci 45
12. Electricity conducted and generated by the earth. Mr. A. Bain 50
13. Instrument for measuring resistance of wire. J. P. Gassiot . 53

Royal Institution:—
   On the phenomena of Induction. Prof. Faraday . . . 55
   On the Gaseous Voltaic Pile. Prof. Grove 57
   On Electro-metallurgy. Alfred Smee 59
   On the Electricity of Steam. Prof. Faraday . . . 60

Institution of Civil Engineers:—
   On Electro-zincing. Mr. F. Pellatt 63
   Electro-magnetic telegraphs. Pf. Wheatstone 64

Reviews and Notices:—
Philosophical Magazine:—
   Hydro-electric machine. W. G. Armstrong . . . 65
   On the Gaseous Voltaic Pile. Prof. Schœnbein . . 65

Page

Reviews, &c., (*continued*).
   On the Phenomena of Induction. Prof. Faraday . . 66
   On the electrical origin of chemical heat. J. P. Joule 67
   Note referring to Static Induction. Prof. Faraday . . 67
   A pile without oxidizable metals. Alex. R. Arrott . 67
   Application of electrotype. Dr. R. Mallett . . . 68
   On the electrolysis of salts. Dr. Hare; and reply to the same, by Prof. Daniell . 69
   Against the contact theory. Prof. Faraday . . . 69
The American Journal of Science:—
   Carbon Voltaic Battery. B. Silliman, jun. 70
   Variation of the Magnetic Needle. Mr. Lockwood . 71
Annales de Chimie et de Physique:—
   Note on the contents . . 71

Notices of Experiments, &c.:—
   Experiments on Induction. Prof. Faraday 71
   Electric Phenomena. Prof. De la Rive 72
   Two currents in one wire. Profs. Morse and Fisher.—Torpedo Nobiliana. Dr. Storer.—Electro-zincing. Messrs. Elkington 74
14. Improvements in Electro-plating. M. Ph. Mourey . . 75
15. Increase of action of a single Pair. Prof. De la Rive . . 77
16. Description of the Voltaic Condenser. Prof. De la Rive . 78
17. Telluro-electric Induction. MM. Palmieri and Santi Linari . 80
18. On Moser's Images. M. Masson 82
19. Deposition of Metallic Oxides. M. Becquerel 85
20. State of Electricity in England. Prof. De la Rive . . . 100
21. On the Generality of Magnetism. Dr. De Haldat . . 107

Digitized by Google

Page

22. Gaseous Electric Current. Prof. Matteucci 108
23. Bain's Voltaic Governor. The Editor 112
24. Bain's improved Pendulum. J. Finlaison 116
25. Action at the Anode; Analysis of heating effects; Ignition of the electrodes. Prof. Grove . 118
26. Armstrong's Hydro-electric Machine. The Editor . . 122

Royal Society:—
On the electricity of effluent vapour. Prof. Faraday . 129

British Association:—
Rheo-electric machine. Mr. John Nott 132
Electro-telegraph thermometer. Prof. Wheatstone . . . 135
Circumstances affecting magnets. Dr. Scoresby 136
Calorific effects of magneto-electricity. J. P. Joule . . 138

Reviews and Notices:—
Bain's telegraphs and clocks. J. Finlaison 139
On the nature of thunder-storms, &c. W. Snow Harris . . 142
Manual of electricity, magnetism, &c. Dr. Lardner . . 147
Archives de l'Electricité. Prof. De la Rive 149

Notices of Experiments:—
Gas and water-pipes, electro-motors. Mr. Bachhoffner and J. P. Gassiot.—Printing telegraph. Mr. Yardley.—Electro-lithotomy. Ed.—Magnetic phenomena. Dr. De Haldat . 150
Electro-plating. Major Jewreinoff.—Auro-, platino-, and argento-cyanide of potassium. Mr. A. Meillet.—Coke negative element. Major Jewreinoff.—Elkington's patent . 151
Conductor to Nelson Column. W. Snow Harris.—Lightning.—Influence of a lightning-rod. Ed. 152
De la Rive's promised work.—Palladium points. Dr. Elice.—New electroscope. Prof. Majocchi.—Magnetic pictures. Dr. De Haldat.—Lightning.—Electro-etching. Dr. Pring.—Gymnotus Electricus. Ed. . 154
27. On the Oxyhydrogen battery. Prof. Schœnbein . . . 155
28. Current passed through 160 miles of wire. Prof. Morse . 164

Page

Law of conduction of wires. Dr. Draper 166
29. Strasburgh Cathedral struck by lightning. M. Fargeaud . . 167
30. Electric pictures or electrographs. M. Pinaud . . . 174
31. Calorific effects of magneto-electricity. J. P. Joule . . 178
32. Natural voltaic pairs. Editor. 190

Royal Society:—
On the gas voltaic battery. Prof. Grove 193
Instruments to determine voltaic constants. Prof. Wheatstone 201

British Association:—
Description of a galvanometer. J. P. Joule 209
Iodine and fluorine, electro-negative. Rev. J. Knox . . 209
Electricity of steam. W. Armstrong 210
Magnetic variations. Prof. Lloyd 210
Electro-magnetic Meteorological Register. Prof. Wheatstone . 212
Observatory at Kew. Professor Wheatstone 213
Simultaneous magnetic observations, &c. Sir W. Herschel . 214

Society of Arts:—
Manufacture of plated goods. Mr. F. Potter 217
Electro-zincing and electro-coppering. Mr. F. Pellatt . 219

London Institution:—
On the correlation of physical forces. Prof. Grove . . 220

Reviews and Notices:—
Magnetical investigations. Dr. Scoresby 222
Days of unusual magnetic disturbance. Lt.-Col. Sabine . 227
Archives de l'Electricité. Prof. De la Rive 228
Lectures on electricity. H. M. Noad 228
New books 229

Notices of Experiments:—
Remarkable fulgurite. Mr. Fiedler 229
Fox's Galvanometer.—Electro-cloth. Mr. Phillips.—Patent electro-cloth. Elkingtons . 230
Substitute for plumbago. Elkingtons.—Steam-jets. Prof. Faraday.—Electricity to discover submerged metals. Lieut. Ramsleтt 231

Digitized by Google

Page

NOTICES, &c., (*continued.*)

Amalgam of sodium for negative element. M. HENRICI.—Magneto-electric battery. Prof. WHEATSTONE.—Bunsen's Carbon battery.—Plating white metal. Mr. TYLER.—Torpedo Occidentalis. Dr. STORER.—Pure hydrogen by electrolysis. Prof. BRANDE . . . 232

Diaphragm battery. ELKINGTONS.—Electricity for springing mines 233

Blasting by magneto-electricity. Mr. WATKINS.—Chemical action of electric light. Prof. DRAPER. 234

33. Electric transfer of ponderable matter. M. FUSINIERI . . 235

34. Influence of flame on electricity. PETRINA 247

35. On the coloration of metals. M. BECQUEREL 251

36. Electrical photometry. M. MASSON 272

37. Universal galvanometer. Prof. MAJOCCHI 275

38. Ignition of metals. Mr. MACKRELL 277

39. Action of buried plates. Rev. F. LOCKEY 279

40. Fracture of Leyden jars. G. H. BACHHOFFNER 281

41. Case of ball lightning. Capt. J. STEWART 283

42. Roberts's voltameter. EDITOR . 284

43. Hydro-electric machine. The EDITOR 285

44. Rheo-electric machine. Mr. J. NOTT. 292

LONDON INSTITUTION:—

On the progress of science. Prof. GROVE 294

ROYAL INSTITUTION:—

On electric conduction; and matter. Prof. FARADAY . . 295

Electricity as a motive power. Prof. GROVE . . . .

REVIEWS AND NOTICES:—

Electrical experiments. G. FRANCIS 300

Damage to ships by lightning. W. SNOW HARRIS . . . 301

Electro-gilding and plating. F. WERNER 302

Electrotype manipulation. CH. V. WALKER 302

Noad's Lectures on Electricity. (Second notice) . . . 302

Page

REVIEWS, &c., (*continued*).

Electro-metallurgy in the arts. ELKINGTONS 305

Catalogue of electrical instruments. Mr. WATKINS . . 306

New Books 307

NOTICES OF EXPERIMENTS, &c.:—

Electricity as a motive power. WAGNER 308

Effects of lightning. S. S. HALDEMON.—Variation and dip. W. MITCHELL.—Matter. Prof. FARADAY.—Accident by lightning. The EDITOR . . 309

Electro-plating and gilding. E. TUCK; Mr. WOOLRICH.—Ozone. Prof. SCHŒNBEIN . . . 310

Black as a conductor. M. SELLIEN. —Frictional electricity. M. PELTIER 311

Electro-blasting. R. W. THOMPSON.—Electricity in place of gas 312

Equivalent of zinc. M. FAVRE.—Terrestrial magnetism. M. AIME. — Magneto-electro-plating. M. DUGARDIN.—Electricity with thermography. Mr. HUNT 313

Voltaic reaction. Prof. GROVE . 314

45 Electric transfer of matter. Pf. ZANTEDESCHI 315

46. Electro-chemical decomposition. ED. BEQUEREL . . . 320

47. New constant battery. Prince BAGRATION 322

48. Intensity of voltaic light. MM. FIZEAU and FOUCAULT . . 325

49. The same continued. MM. FIZEAU and FOUCAULT . . . 333

50. Magneto-electro-telluric battery. MM. PALMIERI and SANTI LINARI 335

51. Voltaic induction. ELIE WARTMANN 337

52. Observations on Wheatstone's constants. Prof. DE LA RIVE . 346

53. Measure of velocity of projectiles. Prof. HENRY . . . 350

54. Surface residence of magnetic force. Dr. DE HALDAT . . 353

55. New electrical machine. MARTYN ROBERTS 358

56. Preparation of carbon cylinders. Dr. M'CULLOCK 360

57. Wadham's galvanic clock. Rev. F. LOCKEY 361

58. Electro-metallurgy in the arts. ELKINGTONS 363

59. Electricity of cloud and fog. ANDREW CROSSE . . . 368

Digitized by Google

Page

60. Terrestrial magnetism. John Nott 371

Royal Society :—
Experiments with water battery. J. P. Gassiot . . . 380
Electrolysis of secondary compounds. Prof. Daniell and Dr. Millar 381
Ozone produced by chemical means. Prof. Schœnbein . 383

Royal Institution :—
Recent researches in electrochemistry. Dr. Millar . . 384

Reviews and Notices :—
Catalogue of magnetic, &c., instruments. Mr. Watkins . 384
Real nature of the electric fluid. James Glenn 386
New Books 386

Notices of Experiments, &c. :—
Electrolysis. Mr. Connell.—Watch melted by lightning . 387
Thermo-electro-plating. Mr. Poole 388
Priestley's spots. Prof. Matteucci.—Electric flame. M. Bunsen. — Loadstones improved. M. Billand . . 389
Physical science in England. Blackwood.—Applications of electro-magnetism. Professor Wheatstone. — Atmospheric electricity. M. Duprez . . 390
Steel for magnets. M. Kupffer.—Electricity of mountains. M. Peltier. — Signal apparatus. Rev. F. Lockey . . . 391
Deposition of metals. Dr. Wollaston. — Electro-telegraph. Mr. Bain. — Electro-motive force exalted. Prof. Grove.—Electro-specula for telescopes. H. Fox Talbot . . . 392
Immersed plates. K. T. Kemp.—Electrical safety-lamp. — Action of buried plates. Rev. F. Lockey 393
Galvanoplastic. Prince Bagration. — Galvanic Daguerréotype plates. M. Daguerre.—Magnetism extraordinary . 394

61. Ships protected from lightning. W. Snow Harris . . . 395
62. Peltier on atmospheric electricity. M. Martens . . . 407

Page

63. Electricity of the atmosphere. M. Peltier 412
64. Different species of fogs. M. Peltier 416
65. Remarks on Peltier's fogs. M. Crahay 418
66. Reply to the above. M. Peltier 420
67. On certain electric phenomena, (in reply). M. Crahay . . 424
68. Atmospheric electricity. M. Peltier 428
69. Electro-motive force exalted. M. Poggendorff . . . 433
70. New form of galvanic battery. Dr. Pring 441
71. Phosphorogenic emanation. Pf. Henry 444
72. Electricity from jets of vapour. M. Peltier 450
73. Electricity of high pressure vapours. M. Peltier . . 453
74. Electricity in manufacturing iron. Arthur Wall . . 457
75. Electircity produced in paper-making. W. G. Armstrong . 459
76. Electricity without contact of elements. J. P. Gassiot . . 463

Royal Society :—
Experiments with a water-battery. J. P. Gassiot . . 465

Reviews and Notices :—
The meteorology of thunderstorms. W. Snow Harris . 470
Manual of electro-metallurgy. Geo. Shaw 471
New Books 471

Notices of Experiments, &c. :—
Longitude determined by electric telegraph. Prof. Morse . . 471
Decomposition of nitrogen. Prof. Schœnbein. — Telegraph with hydro-electric machine. Rev. H. Heighton.—Magnetic telegraph 472
Wheatstone's electro-chronoscopes 473
Atmospheric apparatus at Royal Observatory. — Electro-physiology. Prof. Matteucci . . 474

77. Instruments for electro-physiological research. Pf. Matteucci . 475
78. Mode for studying electro-physiology. Prof. Matteucci . . 482
79. Relation between currents and contractions. Prof. Matteucci and A. Longet 490
80. Measure of nervous force. Prof. Matteucci 497

Digitized by Google

Page

81. Electricity in manufacturing processes. James Napier . . 499
82. Electricity produced in paper-making. Dr. Hankel . . . 501
83. Lightning conductors at Royal Exchange. Cha. V. Walker . 503
84. Has Captain Warner a secret? Mr. Colt 507
85. Direction of needle in China. M. Biot 509
86. Illumination by electricity. W. H. Weekes 516
87. Magnetic note. C. V. Walker 527

Royal Society:—
Electrolysis of secondary compounds. Prof. Daniell and Dr. Millar 529

British Association:—
On the analogy of light, heat, &c. John Goodman . . . 535
Magnetic manipulation. Dr. Scoresby 535
Method of electrotype. Captain Ibbetson 535
Gassiot's electricity without contact. Prof. Grove . . . 535
Nervous force developed by electricity. Prof. Matteucci . 536

London Institution:—
History and philosophy of electricity. Prof. Grove . . 536
Mr. Gassiot's Electrical Soiree . 537

Reviews and Notices:—
Experimental researches in electricity. Part II. Pf. Faraday 538
Traité des phenomènes électro-physiologiques. Prof. Matteucci; Etudes anatomiques, &c. M. Paul Savi . . 542
New Books 550

Notices of Experiments, &c.:—
Double flash of lightning. M. Peltier.—Continuous thunder. M. Chaniet.—Galvanic rings 551
Proposed prize in electricity.—Thunder.—Improved hydro-electric machine . . . 552
Frequency. Beccaria.—Railway Act and electro-telegraphs.—August meteors. Dr. Forster 553
Daguerréotype prints. Rondoni.—Colouring Daguerréotypes.—Prof. Page.—Electrolysis of double cyanides. Mr. Napier. Daring experiment by Galvani. Omnia 554

Page

88. Electro-magnetic and other vibrations. Wm. Beatson . . 555
89. Voltaic reduction of brass. Jacobi 559
90. Phenomena attending lightning flashes. Peltier . . . 562
91. Galvanometer as a time-measurer. Pouillet . . . 565
92. Terrestrial electric currents. Becquerel 570
93. Conductibility of the earth. Matteucci 587
94. Transmission of electric currents through earth. Matteucci . 593
95. Telluric electro-motive force. Mangrini 593
96. Surface residence of magnetic force. Dr. De Haldat . . 597

Royal Institution:—
On the voltaic arc. Prof. Grove. 599

London Institution:—
Discoveries in physical science. Prof. Grove. 601

Chemical Society:—
On the decomposition of metallic salts. Jas. Napier . . . 601

New Books 602

Notices of Experiments, &c.:—
Rousseau's diagometer . . 603
Electro-telegraph. Wheatstone and Cooke.—Electro-cultural Society.—Human muscular currents. Matteucci.—Faraday For. Assoc. French Acad.—Judicial service of electric telegraph 604
Elasticity influenced by electricity. Wertheim.—Constant pile. Desbordeaux.—Reduction of Freycinet's observations. Duperrey—Durertype. Dircks 605
Buried plates. Lockey.—Electricity appropriated by surgeons. Smee.—Electric clocks. Bain.—Electro-telegraphy. Heighton 606
Galvanic rings.—Polarization of electrodes 607
Odd influences of electro-magnetism. Dr. Sommé . . 608
Wagner's electro-magnetic machine.—Magnetic disturbance. Lamont.—Galvanometer in a storm. Quetelet.—Electrodes and eléctrodes . . . 609
Polarity given.—Magnetization.—Matteucci receives Copley medal.—Galvano-culture . 610

Digitized by Google

	Page
Longitude by electro-telegraphs. Wheatstone. — Photographic engraving. Fizeau . . .	611
Hydro-electric machine.—Blasting by galvanism. — Electro-telegraphy in France.—Water-spout	612
Calculus treated by electricity	613
Omnia	614
Death of Prof. Daniell .	614
Index to names	615
Analytic Index	620

Digitized by Google

ADDRESS TO OUR READERS.

DID not good taste prompt us to be very brief in our introductory observations, we could find an all-availing inducement in the great accumulation of interesting matter now lying before us, better deserving a place in this Magazine than any dilated Preface of ours. Avoiding, therefore, any lengthened train of argument in favour of our undertaking—and we might possibly adduce many good reasons for believing that the demand for such a publication as this has long preceded the present attempt to meet it—let us at once lay before our readers the origin and design of THE ELECTRICAL MAGAZINE.

The Publication of the "Proceedings of the London Electrical Society" having ceased, we were strongly urged by many, who were in the habit of reading them, against allowing the numerous channels of information, which had been opened out to us, to be dried up; men who were more acquainted with the under-working of that current, which was as yet but imperfectly represented in those pages, were aware that our resources had grown around us, and that our machinery was, as it were, in good working order for enabling

Digitized by Google

us to be an organ by which the public might keep pace with the rapid advance of Electrical Science. The reiterated entreaties of our friends, and our own experience of the inconveniences attending the want of some such general magazine—a magazine wholly devoted to Electricity, and moving on with the swelling tide—have induced us to continue our intimacy with the lovers of Electricity, and again to exercise our humble abilities in the furtherance of that science. The day of publication was so near at hand when our arrangements enabled us to accede to the wishes of our friends, that we must ask our readers to be lenient toward us, in respect of any deficiencies which may present themselves in the several departments of the First Number. This request is especially urged in reference to the *Reviews:* we have several electrical works before us, to which we could not do justice in a hasty notice, and have therefore deferred them, that we may present a fair digest in a future number.

The most prominent feature of our magazine will be that its pages shall contain translations of the various papers, which appear in foreign journals: these will be given entire, or in abstract, as circumstances may demand; and it will be our earnest endeavour to obtain them, as soon after their publication as possible, so that the English Electrician shall not again, as in the case of Ohm's law, be for years in ignorance of the important progress making in this science by our continental brethren. Great care will be bestowed on the translations in order to give the true spirit of the respective authors.

We do not purpose depending on original contributions, as our resources; our pages are open to them; and we shall give every new and good communication a very ready wel-

Digitized by Google

come; and we hope so to conduct our magazine that electricians may recognise it as the fitting channel, through which to communicate their discoveries.

We intend presenting, as the case may require, full or condensed reports of Lectures on any new phenomena in Electricity; and abstracts of papers read before the scientific bodies in the metropolis and elsewhere.

We will give a resumé of any thing of note that appears in the pages of other journals; and endeavour to glance over all new electrical publications of value which may from time to time be issued from our own, or from the continental and transatlantic press. At least we will do this as far as our limits will allow. And we will find a few pages for short notices of new experiments, electrical anecdotes, and such other matter as may promise to interest the reader.

The character which we hope may pervade our Magazine will be its keeping pace with the times. We desire so to conduct it that our readers may feel assured that they will find in it *everything new and important that occurs.*

One word with respect to the contents generally:—In our editorial position we hold not ourselves the champion of any one theory in preference to any other. Our pages will continually present features, in which one philosopher is seen to hold views greatly opposed to another; but each must speak for himself. We have our private opinions, but these shall not interfere with our public duty of reporting accurately the reasons on which the faith of those who differ from us rests. Let it not be understood, however, that we intend advocating controversial writing: our habits are the reverse to this, and while men differ, as they ever must, so long as finite is studying the works of INFINITE, let them

Digitized by Google

The following questions now arise; Is the image, that is thus called forth, produced by traces of electricity still adhering to the plate of glass? Has it been caused in a similar manner to those of Möser, that is to say, by light? Can similar images be obtained likewise on metal? What are the conditions for obtaining these pictures with success? In what way can they be fixed?

The first of these questions I must answer decidedly in the negative; immediately after it is electrified, the plate, it is true, does manifest a trace of electricity: by wiping it, however, with a cloth, or by letting it stand for a considerable time, this trace of electricity disappears altogether, yet the image is given with the greatest precision; indeed even though the plate is well rubbed, warmed and breathed upon, it is a hard matter to get rid of all traces of the image; and this, indeed, is often troublesome in performing the experiments. Another argument against the supposition, that a trace of electricity can be still adhering to the plate, is this, namely, that the picture is not weakened or effaced on directing the opposite electricity upon it; besides both kinds of electricity produce precisely similar effects.

What, however, is quite decisive upon this point is the circumstance that, (by observing certain precautions, which I will explain directly,) I have also obtained these images upon polished metal plates, in which there can be no question of any adhering electricity. The actual presence of electricity is, therefore, not the cause of these images.

It cannot be so readily decided whether their origin is due to causes similar to those that develop Möser's pictures, or whether they are to be attributed to a peculiar influence of electricity. What militates against the former of these views is, that the process is completed in an extremely short time, compared with what is required for the production of Möser's pictures. A few turns of the machine suffice for the production of the outlines of the medals on the glass; and the time that is required for 300 turns, this giving the quantity of fluid required for the production of images on metal plates, is, comparatively speaking, only very limited.

But to this it may, perhaps, be objected, that the intensity of the light is so considerable that this short time is sufficient for producing the picture. To this we may reply that shocks from a battery, the light from which is beyond all question considerably brighter than that of sparks, do not produce so distinct a picture as sparks do. Besides, I insulated the medal, by means of sealing-wax, and retained it at the distance of a line from the glass, so that the sparks passed over at once

Digitized by Google

from its edge to the plate of metal; yet I, nevertheless, obtained an image; and this without there being, even in the dark, any visible display of light whatever, between the medal itself and the glass plate.

There would be thus nothing left for us, but the so-called dark or invisible rays of light; but even these do not, that we are aware of, produce such intense effects as those in question; and we should, therefore, be forced to assume that, in the electrical light, or electric fluid, there is a marked and special abundance of that species of rays, which induce those superficial changes of which we are here treating. As there is at present, however, no ground for such an assumption, we must, as the matter now stands, attribute the effect in question to some peculiarity in electricity.

With respect to the conditions to be observed for insuring success with these pictures, what I have been able to ascertain with certainty up to this time is as follows. First, a good deal appears to depend upon the quality of the glass;—the pictures are produced, with equal distinctness, on thick and on thin glass, excepting when coins are applied to both sides of the plate, in which case they act as coatings. With thin glass many plates may be laid upon each other, and on each there is given a recognizable impression of the medal, though indeed gradually becoming less distinct. Difference in the chemical composition of the glass produces a marked difference in the figures; for, other circumstances being alike, I have obtained pictures of very unequal goodness upon glass of different composition. It appears to be immaterial whether the knob from the conductor is brought into contact with the coin, or whether the sparks strike down upon it. The sharpness of the impression is, on the other hand, very materially increased, when the sparks strike off freely from the coin into the external plate of metal; and in those cases where the fluid escaped from the medal but slowly, the images were indistinct.

The best images that I obtained on metal plates, I got when I laid a piece of oiled paper between the plate and the medal, by which the transmission of the electricity was somewhat retarded; images were, however, also produced when the medal was in immediate contact with the plate. I cannot take upon myself to say for certain that the nature of the metal of the coin itself has an influence in the matter; but it appeared to me that those composed of the best conductors produced the clearest images. As has been already remarked, strong shocks from a jar or a battery do not bring about the same effects as single sparks, at least with a bat-

STANFORD LIBRARIES

Digitized by Google

tery one must give quite as many turns of the machine, (and with a jar indeed more,) to obtain a picture of equal precision. There may be several reasons for this, partly from a residual charge remaining in the jar, and also in the battery, and this causing a diminution in the actual amount of electricity imparted; partly also from the effect of the machine being essened the nearer the jar or the battery approaches to a charged state. Positive and negative electricity appear to be equally effective in their results; but I have not yet performed experiments enough to settle this point.

With regard to fixing the pictures, I have, as yet, succeeded but very imperfectly on this head. The pictures upon the plates of glass were, it is true, developed by an exposure to the vapours of mercury and iodine; they, however, disappeared as soon as they were removed from the apparatus. The pictures on the metal plates, on the other hand, were fixed by the iodine and mercury vapours, not however uniformly, or with distinctness; this, however, may be owing partly to a want of dexterity in the manipulation, and partly to the faulty construction of the apparatus.

From the necessity of interposing an imperfect insulator, when obtaining the most satisfactory results upon metallic plates, it occurred to me to try to produce pictures by means of the galvanic current; as yet, however, I have not by this means obtained more than the trace of an impression. There is no doubt, however, that successful results will follow from a suitable modification of this process. Should the continuation of my experiments lead to further results, I will not fail to communicate them to you.—[L.]

II. *On Impressions or Pictures produced by Electricity.* By G. Karsten. From Poggendorff's "Annalen der Physick," vol. lviii. p. 115. Translated and communicated by W. G. Lettsom, Esq.

1. From continuing my experiments on electrical images,* I have arrived at the following results: 1st, I have been able to establish, more accurately, the conditions under which successful images are obtained; 2nd, There is a difference observable, according to the electricity employed; 3rd, The electrical pictures are essentially different from those produced by light, whereas, they appear to be identical with

* See vol. lvii. p. 492; and the translation p. 5, *Elec. Mag.*—L.

Digitized by Google

those produced by what Professor Möser terms the invisible rays; 4th, The production of these images by galvanism is yet in doubt; magnetism, however, does produce them; 5th, These pictures are produced by heat, and that, when applied in various manners; the conditions, however, under which they are thus called forth, are not as yet clearly made out.

It has been already stated, in the former paper, that images are produced with distinctness on glass, only when the sparks strike off from the coin into the metal plate, on which the glass rests. This I am enabled to confirm, with the addition, that the image is so much the more distinct, the more frequently the spontaneous discharge of this coated plate, formed by the coin and the plate of metal, takes place. This appeared to indicate that a continuous current of electricity is required for the production of distinct images, a supposition which is borne out by the conduct of imperfect conductors, upon which the images were produced with great precision, the electricity escaping thence but slowly. The coin, upon these occasions, appeared encircled with a crown of rays, arising from the continuous nature of the discharge. In experimenting upon metal plates, this operation must be reversed. If it was requisite, when employing plates of glass, to get rid of the electricity, and prevent its accumulation thereon, so, on the other hand, when operating on metal plates, was it necessary to reduce the velocity of the electricity. As observed in my preliminary notice, I at first had recourse to a piece of oiled paper, inserted between the coin and the plate; I now, however, made use of a thin piece of glass, or, which is far preferable, a film of Siberian mica; by this means, with not more than fifteen or twenty turns of the machine, that is to say, in an interval of from ten to fifteen seconds, I obtained an extremely distinct picture. The thinner the insulator is, or, in other words, the more completely the opposite electricity is disguised, the more distinct the image is, and the more rapidly is it obtained. The following experiment may be adduced in proof of this. Two films of mica were laid upon a metallic plate, in such a manner that, at the centre, they formed a double layer, whereas, toward the edge, the layer was but single. After fifteen turns of the machine, a coin laid on this plate, gave a very distinct image towards its circumference, whereas the central portion came out but weakly. The most precise images are obtained likewise here, when the spontaneous discharges of this miniature battery follow in quick succession. Since the image, which is formed by the passage of the spark from the positive conductor, is, in point of fact, to be attributed to the negative

Digitized by Google

electricity, disguised on the metallic plate. I shall, in the sequel, term this a NEGATIVE ELECTRICAL image; on the other hand, the picture obtained upon a negative conductor, I shall call a POSITIVE ELECTRICAL image. This of course applies only to pictures formed upon metal plates. From these experiments, therefore, we draw the inference, that it is a requisite condition for the production of distinct images, that the velocity of the electricity should be modified.

Various modifications of the experiment were made, both with regard to the plates, and likewise the objects to be figured. By way of plates, there were employed white and coloured glass, marble, porphyry, granite, syenite, satin-paper, wood, horn, rosin, silver, copper, German silver, tin-plate, steel, zinc, and various metallic alloys. The phenomena were very remarkable, when a polished plate of diorite, from Sweden, was employed for the experiment. This substance consists of a mixture of albite, horneblende, and interspersed portions of magnetic iron ore. When a film of mica was inserted between the coin and the plate, the image became visible only on the metallic points scattered about on the stone. When no film of mica was inserted between them, the picture was produced only on the albite and the horneblende, not however with equal distinctness on each. On the magnetic iron ore there was no image at all. Something similar may be observed with all compound minerals. We here see very evidently that the conducting power of the various substances is not to be overlooked. Perhaps we shall thus have it in our power to ascertain the relative conducting power of certain bodies. Nor were the objects to be figured less varied than were the plates; coins and medals of various metals were employed, as were also seals, cut stones, other minerals, and likewise glass and paper. The film of mica, inserted between the coin and the plate, never failed in being given with remarkable precision. Here also minute distinctions were rendered accurately; and this was carried so far that the paper impression, from a divided circle, engraved upon copper, was reproduced with precision upon a metallic plate, with its fine divisions. Generally, however, I made use of various pieces of money for my experiments, on account of the equality of the stamp. On producing an image on a plated silver-plate, similar to those employed for Daguerréotypes, this extraordinary circumstance presented itself, namely, that, after a great number of turns of the machine, the image of the coin, and of the film of mica, were distinctly impressed upon the plate as it was, without the employment of any vapours; and this engraved coin, as it were, presented itself

Digitized by Google

in dispersed light, with a brown, and, in reflected light, with a bluish white colour. I at first attributed this to traces of iodine remaining on the plate, or to those of other substances employed in polishing it. Hypo-sulphite of soda, however, or diluted nitric acid did not alter the image in any way. In order to make certain, however, I employed perfectly new plates, which presented the same phenomenon; with 1000 turns of the machine, the whole picture was, as it were, etched into the plate; and, with 2000 turns, the intensity of the brown colour was heightened. A perfectly new silver coin had apparently lost its polish at those parts, whose image was impressed on the plate; yet, the notion that any metallic particles could be transferred from the coin to the plate is quite inadmissible, owing to the insertion of the film of mica between them. By the formation of sparks between the coin and the mica film on the one hand, and the metal plate and the coin on the other, it is possible that very minute quantities of nitric acid might be formed; it, nevertheless, does not appear admissible to attribute these effects to such a cause, inasmuch as the colour of moistened litmus paper did not undergo any visible change. I have, in my subsequent experiments, often observed a repetition of these phenomena, but only when plated or metal plates were used; at any rate, it appears to me, a process altogether independent of the formation of the image, inasmuch as the latter is already produced in the greatest beauty after twenty turns, whereas many turns are required for etching an image thus into the plate.

2. In the first notice, above referred to, I stated that the effects due to + or — electricity were similar. As yet, however, nothing is satisfactorily established on this head. In so far it is true that the effects from both kinds of electricity are alike, namely, that the application of aqueous vapour brings out with equal distinctness, and that whether on glass or on metal the image produced either by + or — electricity, or by a combination of both. I have not been successful in imparting to the coin directly precisely equal quantities of the two electricities, inasmuch as my machine has separate conductors, and the effect from the + conductor is much stronger than the other; but I could observe no difference on employing the sparks drawing from the outer coating of a jar, provided with a Lane's discharging electrometer. Aqueous vapour, the original application I had recourse to when I first obtained distinct pictures, (and up to now the best,) shewed decidedly no difference; upon every occasion the raised portions of the coin remain unwetted. On

Digitized by Google

breathing upon the plates, one could almost make out two kinds of breath,—that is to say, one remarks, first, that the breath spreads itself uniformly and with rapidity over the entire plate; and, secondly, that at certain places, especially where the image lies, it is absorbed, as it were, by the plate, a phenomenon much resembling that presented by water when it extends itself between two plates of glass almost in contact with each other. Besides, the first breath disappears rapidly, whereas the second remains attached to the metal a long while. Although there is a great similarity between the electrical pictures brought out by aqueous vapour, nevertheless there is a difference to be observed, as was rendered evident upon fixing them by the vapour of iodine or of mercury. We sometimes obtain images, in which the salient parts of the coin are more affected by the vapour than the rest; sometimes the reverse of this is the case. The first kind of picture presents the effect of a coin in relief; the second that of a coin in intaglio. At first there appeared to me to be no rule whatever for the development of the one or the other kind of image. The distinction between positive and negative pictures, which, in the opinion of Professor Möser, is, in the light pictures, to be attributed to the tension of the vapours, does not for a certainty obtain with respect to the electrical pictures. I subsequently remarked, however, that a *negative electrical* picture, produced by a few turns of the machine, gave, when fixed with the vapour of iodine, a negative or intaglio image; a *positive electrical* picture, on the other hand, gave a positive image,—in other words, one in relief. It is remarkable how in this case the terminology ordinarily employed in electricity adapts itself to the name introduced by Herschel in a totally different field of enquiry. The precision of the pictures was no way increased when the iodized plates were exposed to the vapour of mercury. The *negative electrical* pictures were not so frequently well fixed by iodine vapour as the *positive electrical.* If, on the contrary, fresh plates were first exposed to the vapour of mercury at a temperature of 167° Fahr., and then had the picture produced upon them, the vapours of iodine then fixed the negative electrical image too, and that with great precision, though not unfrequently as a *positive* picture; whereas, the *positive electrical* pictures were no ways improved by the process. I have not been able to detect anything like regularity in the transition of *negative electrical* pictures into positive ones, owing to the previous application of mercurial vapour, although it appears to me as though the quantity of the elec-

Digitized by Google

tricity employed was of considerable influence thereon, as is indicated by the following series of experiments :—

Nature of the Electrical Picture.	No. of Turns of the Machine.	Nature of the Picture after Iodization.
positive	30	positive.
positive	100	weak negative.
positive	200	negative.
*positive	30	positive.
*positive	100	weak positive.
*positive	200	indiscernible.
negative	30	negative.
negative	100	weak positive.
negative	200	positive.
*negative	30	weak positive.
*negative	100	negative.
*negative	200	positive.

In the experiments marked with an asterisk, the clean plate was exposed to the vapours of mercury at 167° Fahr., previously to the picture being formed upon it.

I am far from looking on the result as constant, or indeed from drawing any decided inference from these experiments; the amount of electricity would, however, appear to affect the nature of the picture produced; but what law this influence follows, I cannot at present determine. The positive pictures, that have proceeded from *negative electrical* ones, are distinguishable by their colour from those originally *positive*; the latter, upon brass, are of a blue colour; whereas the former are of a beautiful golden yellow. The experiments here described were all performed upon brass plates; for I have not yet been successful in fixing the pictures on silver, although aqueous vapour brought them out with great precision. The metallic nature of the plate itself appears also to exert an influence on the kind of picture that is produced; but, up to the present time, the whole affair is too undecided to admit of any determinate opinion in the matter.

3. On reviewing all the peculiarities by which these electrical pictures are distinguished from those produced by light, we arrive at the conclusion that they are identical with those of Professor Möser, produced by the invisible rays. The first thing that points out a distinction between pictures produced by electricity and those produced by light, is their conduct with regard to the fixing vapours. The vapour of mercury does not bring out an electrical picture, whereas the vapour of iodine does. If the same process is pursued with the elec-

Digitized by Google

trical pictures as with daguerréotypes, no result whatever is obtained; that is to say, if an iodized plate is taken, and a picture produced thereon, the vapour of mercury will not bring it out, although the image really is on the plate, as may be shown by breathing upon it. On exposing an iodized plate, with the image already on it, to the rays of the sun, the picture is thereby brought out, the entire plate blackening, with the exception of the picture, which loses its colour, or becomes paler at least,—in other words, it comes out as a negative picture. Some change, it is true, has been thus worked in the iodine, and thus far electrical pictures and daguerréotypes agree; the modification itself, however, is essentially different. With electrical pictures the effect is such as is brought about by and upon bodies of every kind; whereas in daguerréotypes the iodine is affected in a way peculiar to itself alone. Generally speaking, it seems somewhat a remote question to enquire whether these pictures are caused by light or by heat. Supposing the pictures had been first produced by means of electricity, would it ever have then occurred to any one to attribute the effect to the electrical light or to an excitation of heat by this fluid? Assuredly not; the pictures would doubtless have been attributed to some peculiar property of electricity. This enquiry will be quite superfluous, should it be established that these pictures are similar to those produced by the invisible rays; and that this is the case is evident from all the phenomena. On comparing, for instance, the properties of both kinds of pictures, *die beim nivelliren* hervortreten*, (?) it will be found that they are precisely alike. Pictures produced by the invisible rays *werden durch keine Farbe nivellirt, auch nicht durch sich selbst*, (?) and this is also the case with electrical pictures. Blue, violet, (aqueous vapour, vapour of iodine, according to Professor Möser,) and the daylight or sunshine, develop the pictures of the invisible rays; the effect is begun thereby, just as is the case with the electrical pictures. Red and yellow (vapour of mercury), on the other hand, do not allow of the pictures coming out, or at least only after a very long interval. This is also the case with the electrical pictures; and, moreover, the fact that I have stated of an electrical picture on an iodized plate not being brought out by mercury, is also in harmony herewith. In short, all the phenomena bear out the notion that the electrical pictures belong to the family of those developed by the invisible rays; but the inference that

* The word *nivelliren* may possibly mean "expunge" or "efface," though in its *usual* direct and metaphorical senses it means "render level," or "reduce to a level."—L.

Digitized by Google

I should, for that very reason, draw from them would be, that these invisible rays of light were not light at all. At all events, the name selected does not agree with the peculiar character of the phenomenon. Professor Möser says himself that the invisible rays form no part of the light of the sun,—that they, however, belong to all bodies; in this case, it is not, however, light, but the operation of some power possessed by all bodies in common. The connecting link between pictures truly formed by light, and those caused by the invisible rays, is simply this, that both indicate an altered condition of the surfaces of the bodies; and that this modification is more decided in the case of the pictures caused by the invisible rays than the others. The whole of the phenomena indicate modifications of cohesion; light, heat, and electricity, have this one point common to them all, and I therefore am led to the conclusion, that the cause is to be sought much rather in cohesion than in light. But how can one as yet touch upon the essential nature of a thing, the facts concerning which are so far from being established?—a truce, therefore, to all hypothesis. The effect of light upon the iodized plates is similar, be the metal what it may. Although, as before stated, I was not successful in obtaining pictures on silver plates, by the application of iodine in a state of vapour, yet I found that light brought out on silver, and also on plates of other metals, the *electrical* pictures impressed on the iodized plates. Professor Möser makes no distinction between the vapour of water and iodine, according to their latent colour; that is to say, he ascribes to each the similar property either of expunging (? *Zu nivelliren*) or developing the pictures. This does not altogether agree with the phenomenon as presented by the *electrical* pictures, inasmuch as the vapour of water always develops them more satisfactorily than that of iodine does; and often indeed brings out sharp pictures, where iodine vapour shews not a trace of them.

4. With galvanism, I have performed experiments on the production of these pictures; but I have not obtained more than equivocal results. A battery of forty pairs of seven inch plates produced no effect, either when the current was led through a piece of money resting on glass or on a metallic plate, or when the coin formed one pole and the plate the other. Nor was the effect from a calorimotor greater, although on closing the circuit it gave good sparks. I obtained, it is true, every time, the mark of the edge of the coin; but as the operation lasted too long, I cannot well say that the image thus obtained was galvanic. By magnetism,

Digitized by Google

on the other hand, I obtained unequivocal effects. An iron medal, resting on a steel mirror, received a certain number of touches, and there was seen on breathing on the steel the edge portion of the medal. It was established by several counter-experiments that these pictures were to be attributed to no other cause. I am therefore of opinion, that successful results might be expected from powerful magnets. It was not in my power to ascertain whether electro-magnetism and magneto-electricity produce similar effects, inasmuch as I had not the requisite apparatus at my command.

5. To conclude:—I have produced very distinct pictures by heat, and this in several ways. A plate of glass, with a coin laid upon it, was placed in the warm stove, and after an interval of five minutes, the plate was removed and cooled. Sometimes the image was seen on the plate's being breathed upon; but, which is very remarkable, occasionally there were no signs whatever of an image till the plate was cleaned off,—a circumstance that I have frequently noticed with these heat-pictures. Metallic plates, submitted to a similar treatment, presented no certain results. When, on the contrary, a piece of money was moderately heated, and a plate momentarily brought into contact with it, a beautiful image, capable of being fixed by the vapour of iodine or of mercury, was often developed. Upon all occasions, when one of these distinct pictures was produced, it was visible even without the application of iodine or mercury vapour, and was of the same bluish colour exhibited by *electrical* pictures formed on silver plates, as described under paragraph 1. I have not yet been able to establish what the conditions are under which these heat-pictures are successfully produced.—[L.]

III. *On the Preparation of the Carbon which is intended to supply the place of Platinum in Grove's Batteries.** By M. Bunsen. From "Archives de l'Electricité," No. 7, p. 103, 5th April, 1843.

(TRANSLATION.)

The new and important application of platinum, resulting from the beautiful discovery of Grove, makes it much to be desired that this precious metal could be replaced by a less costly material. With this intent the employment of graphite has long been suggested, either such as is found in nature, or

* Pogg. Ann. vol. 55, p. 265.

Digitized by Google

such as is obtained by deposition in gas retorts. But the difficulty experienced in working this substance, on account of its excessive cohesion, and still more, the impossibility of making it into pieces of a given form and dimensions, have hitherto prevented the realisation of the hopes to which the moderate price of this substance had given rise. And hence, as I believe, this idea has not received a general application. For my part, I am, on the other hand, convinced by experience that the difficulties hitherto opposed to the general employment of carbon, may be surmounted; because the variety of carbon produced by burning to incandescence carbonaceous organic substances (and which, under favourable circumstances, surpasses even platinum in activity, whether in conductibility or in electro-motive force); I say, because that carbon may be obtained in a mould which permits our working it with the greatest facility, and giving it the form suited to the special end to which it is destined. For this purpose a mixture of coke (baked as well as possible) and of pitcoal, reduced to a fine powder, is subjected to a red heat. If the mass thus obtained is too friable, which is commonly the case when poor pit-coal is used, the proportion of the latter relative to the coke must be increased. If, on the other hand, the pit-coal is superior, the resulting mass cracks, and presents nothing but disjointed fragments. But when once the proper proportion is found, the operation can no longer fail. The mixture is heated over a moderate charcoal fire, in sheet-iron moulds, which are able to stand ten or a dozen operations, without being deteriorated. Should the diameter of these moulds exceed five or six inches; it is rare that a carbon is obtained completely exempt from fissures. But it may easily be obtained under the form of hollow cylinders, of the largest dimensions, by introducing within the iron mould a cylindrical wooden box, and filling with the mixture the interval existing between the two walls. The very great change of volume, which the carbon undergoes during this operation, does not allow of the box being replaced by an empty cylinder of sheet-iron.

The carbon obtained by this means has doubtless already a tolerably solid structure; but its great porosity renders its employment altogether impossible. To render it as compact as it ought to be, and to give it a consistency which scarcely yields to the hardest stones, it is plunged, before the second operation, into a concentrated solution of sugar, made, if we please, with the coarsest refuse of sugar; it is then dried until the sugar has acquired a solid consistence in the mould. The carbon does not acquire conductibility and electro-motive

Digitized by Google

force until it has been exposed for several hours to the action of a very intense white heat, in a covered vessel, capable of resisting the fire, filled with pieces of charcoal, an operation which can very readily be accomplished in an ordinary potter's furnace. The carbon prepared by this method is perfectly homogeneous,—very slightly porous; it does not in the least degree lose its colour; it rings, has a metallic appearance, and is so solid, that a hollow cylinder, weighing six ounces, and three lines thick, can fall on wood, from a height of six or eight feet, without breaking. The best mode of procuring carbon discs, is to take pieces of carbon of a cubical form, and to divide them with the saw into discs one line thick, which are afterwards polished on a plate of grey stone. With a cube of this kind, the value of which is not worth naming, eight or ten discs may be made, which, united in pairs with amalgamated zinc in a Grove's battery, produce an effect equal to that of a piece of platinum, which is worth in commerce from 25 to 30 *écus* (76*s.* to 91*s.*) In a similar manner, with two solid cylinders of carbon, seven inches long, may be procured about 100 discs, which are combined so as to form a pile, with plates of amalgamated zinc, and one exciting liquid, consisting of dilute sulphuric acid mixed with acid chromate of potash, which, without acting on the zinc, supplies the place of nitric acid with respect to the carbon. Such a pile as this produces most powerful effects; it has this advantage, that the carbon, independently of the increase of action which it determines, does not become amalgamated, and that there is no cleansing operation to perform; for it is merely necessary to preserve the carbon in the exciting liquid, and occasionally to boil it in it, in order to expel the oxide of chromium which is deposited in its pores. There is also some advantage in employing hollow cylinders of carbon, instead of discs, because, without difficulty, such dimensions may be given to these cylinders, as that the total surface of each should form a square foot. They are rasped with a tin grater before immersing them in the sugar-solution, and are afterwards reduced to a true cylindrical form and smooth surface.

To prevent the liquids penetrating into the carbon as far as the portions to be placed in communication with the metals, these parts are plunged into melted wax, which is absorbed by the carbon, and destroys its capillarity with respect to other liquids, without weakening in a sensible manner its conductibility.

[The author here describes the details of the construction of his battery; as these details are quite analagous to those

Digitized by Google

which will be found in the extract elsewhere* given from the "Comptes Rendus" of the Academy of Sciences, we will not report them again.]

I am persuaded, adds M. Bunsen, that this apparatus has great advantages over the Grove's battery constructed with platinum; for it not only presents, for an equal consumption of acids and zinc, a perfect equality of force, but it moreover does not require above one-fourth of the expense in construction, being at the same time as elegant, and much more commodious. By combining, so as to make four pairs, exposing a surface of two square feet of carbon, a battery formed of forty-eight pairs of the dimensions named, and which costs in construction no more than a battery of twelve pairs on Poggendorff's plan, an amount of detonating gas is obtained, sufficient to produce the Drummond light; and when they are arranged so as to form forty-eight pairs in series, the magnificent phenomenon, of the arch of light between two charcoal points, is produced.†

I use, moreover, carbon apparatuses, constructed on another plan, and the use of which, although I have not heretofore had an opportunity of describing them, seems to be already pretty widely diffused: I think I have less reason to pass them over in silence, since M. Poggendorff has regarded them as sufficiently important to subject them to his examination in the *Annalen*.

The battery to which I allude exercises an action perfectly equal to that of a Grove's battery. Each pair is composed of a hollow cylinder of amalgamated zinc, immersed in a glass vessel, and of a carbon cylinder placed within the zinc cylinder. The carbon cylinder is hollow in the interior, but it is not pierced in its entire length; the base of the cylinder is filled and solid. The height of the cylinder needs not exceed five inches, nor its diameter two. A conical copper ring is fixed to the upper extremity of the carbon, which is itself saturated with wax; and a conductor, proceeding from the copper ring, is fixed, by means of a binding screw, to the zinc connection of the following pair. The interior of the carbon cylinder is filled with nitric acid, until the whole mass of the carbon is well saturated with it; the excess of nitric acid is then driven off, by blowing with a tube. The carbon, in this operation, does not take up more nitric acid than is

* Vide Elec. Mag., p. 22.

† I paid 10 *gros d'argent* (about 2*s.*) for excellent cylinders of carbon, having 20 to 21 square inches of *inner* surface. Consequently the interior surface of carbon, in a battery of six cells, which amounts to about a square foot, costs 2 *écus* (6*s.*) A surface of platinum, producing the same effect, would cost about 18 *écus*, according to Poggendorff's calculation.

Digitized by Google

imbibed in the porous cells of Grove's battery. The carbon cylinders are then introduced into the interior of the amalgamated zinc cylinders, so as to avoid all contact between them, which is effected by interposing string covered with wax, or bundles of spun glass. The connection is then made between the carbon of each pair, and the zinc of the following pair, by means of the conductors and the clamps, of which we have spoken; and, to put the battery in action, nothing more is requisite than to fill the glass vessels with dilute sulphuric acid. When the apparatus is no longer in requisition, it is taken to pieces, and the carbon is preserved in the glass vessels from which the acid has been removed, or else, if there is a fear of the nitrous vapours which escape, in a vessel covered with a disc of polished glass. I think that the want of neatness, or rather, perhaps, of elegance, is sufficiently compensated for, in this apparatus, by the convenience and simplicity of its construction. In particular I find that, in an apparatus which, like the present, is exposed to the action of acid vapours, the employment of screws must be renounced for the use of clamps, which supply their place in a much more sure and simple manner. If the pieces of metal, which serve to form communication, become covered with a layer of oxide, rubbing them with dilute sulphuric acid is sufficient to restore them immediately to their former brilliancy. The form I have selected appears to me the most convenient and simple for a small apparatus. But it is not suited to batteries of large dimensions, because there is inconvenience in filling large carbon cylinders, and the nitric acid contained in these cylinders must be entirely consumed, without our being able at each moment to replace it, free from loss, by other acid of different strength, as in the batteries constructed after Grove's plan. In general, the apparatus in question requires of the person, who uses it, more care and skill than Grove's; its employment moreover is inconvenient, if not impossible, when the object is to produce at pleasure a current of a given power.

[. . . The author, returning here to the advantages of the substitution of carbon for platinum, begins by reverting to the principle, which serves as the base for the comparative valuation of the power of different kinds of batteries.]

If we set out from the principle that apparatuses of this kind accomplish the end in view better, as the electrical effect obtained by them is greater in proportion to the consumption of the liquid and solid elements of the battery, a simple consideration will suffice to determine the important condition, which their mode of construction must fill.

Digitized by Google

Let us first seek the law, according to which a given number of pairs ought to be combined to produce the maximum of effect. Let a be this number of elements of given dimensions, L, the resistance of conductibility in one of the elements, l, this resistance in the arc of junction, and e, the electro-motive force; the force of the current I for a pairs will be

$$I = \frac{a\,e}{a\,L + l}$$

If x pairs are formed with these elements, so that the surface of each pair separately is $\frac{a}{x}$, the force of the current becomes

$$I' = \frac{x\,e}{\frac{x^2 L}{a} + l}$$

Dividing this value by the former, and calling $\frac{I'}{I} = y$, we have:

$$y = \frac{x\,(a\,L + l)}{x^2\,L + a\,l}$$

If, further, we place

$$\frac{d\,y}{d\,x} = \frac{a\,L + l}{x^2 L + a\,l} - \frac{(x\,a\,L - x\,l)\,2\,x\,L}{(x^2\,L + a\,l)^2} = 0$$

we obtain, as the maximum of the intensity of the current, the value

$$x = \sqrt{\frac{a\,l}{L}},$$

and by substituting A for $\sqrt{\frac{a}{L}}$, we have $x = A\,\sqrt{l}$.

Thus the number of pairs, necessary to obtain the maximum of the force of the current, may be represented by the square root of the resistance of conductibility in the arc of junction.* Consequently, the more feeble the resistance of conductibility in a liquid to be electrolyzed, or the greater the surfaces of the electrodes, immersed in it, or the nearer they are placed to each other, the fewer ought to be the number of elements of the battery, when the greatest possible effect is desired. We have then, by augmenting the surface of the electrodes, a means of reducing to its lowest value, that is to

* We must not omit to observe that, in a liquid, the value of l changes with the force of the current.

Digitized by Google

two, the number of pairs, so that, for two atoms of zinc provided in the battery, one atom of water may be decomposed in the cell.

. . . [M. Bunsen terminated his Memoir by the description of a Voltameter, in which the electrodes are made from the same carbon with which he forms the negative elements of the pairs in his battery. He points out various ingenious means for easily and speedily varying the surface of these electrodes, which he can regulate so as to have many square feet of surface.]*—[A.]

IV. *A Battery on a new Construction, remarkable for its energetic Effects.* By M. BUNSEN. From "Les Comptes Rendus," Feb. 27, 1843, No. 9, p. 503.

(TRANSLATION.)

M. Regnault presents to the Academy, on the part of M. Reizet, a battery on a new construction, remarkable for its energetic effects. This battery, formed of forty elements, and occupying very little space, is equal to the production of all the effects, obtained with Faraday's batteries, of a considerably greater number of elements. The Academy may judge of this by the experiments which have been made in their presence.

M. Reizet makes the following observations on this battery:

During the sojourn I made at Marbourg, in the month of September last, M. Bunsen, professor of chemistry at the University of that city, was kind enough to acquaint me with a new battery of his invention. In this, which is a constant battery, a cylinder of carbon is, in a very ingenious manner, substituted for the platinum plates of Grove's battery.

Thanks to the good instructions of M. Bunsen, the new carbon-battery is now made at Paris; and I congratulate myself in having had the opportunity of contributing towards diffusing in France the knowledge of an apparatus so worthy

* The Memoir of M. Bunsen is accompanied, in the *Annalen der Physick*, by a note from M. Poggendorff, in which this philosopher remarks that the perfection, which M. Bunsen has introduced in the preparation and construction of carbon-cylinders, removes the greater part of the objections, to which, in practice, the first process pointed out by M. Bunsen, gave rise. M. Poggendorff considers that M. Bunsen's battery will be especially applicable when a large apparatus is concerned; but, when a small apparatus is considered, such as that required for purely scientific purposes, the preference should not be given to carbon over platinum.

Digitized by Google

of the interest of philosophers, and so valuable for practical purposes.

The following documents are extracted from the correspondence of M. Bunsen, who himself begged me to communicate them to the public.

Each pair of this battery is composed of four solid pieces of a cylindrical form, which fit easily one in the other. Commencing with the exterior, which contains the rest, the following is the order in which these pieces are arranged:—

1st. A glass vessel filled with the nitric acid of commerce.

2nd. A hollow cylinder of carbon,* pierced with holes, plunged into the nitric acid to three-fourths its height. On the rim, without the vessel, and not immersed in the acid, a ring of well-cleaned zinc is closely fitted; at the upper boundary of this ring is soldered a bent metallic plate, for the purpose of establishing contact with the contrary pole.

3rd. A cell or diaphragm of porous earth, which is introduced into the interior of the carbon cylinder, so as to leave an interval of about two millim. ($\frac{1}{12}$ in.) This cell receives diluted sulphuric acid (one part of the acid of commerce with seven or eight parts water).

4th. A hollow cylinder of amalgamated zinc, which is plunged into the sulphuric acid of the preceding cell. The upper edge of the cylinder is surmounted by a slip (of zinc), suited for establishing contact with the contrary pole.

The union of these pieces constitutes one pair of the new battery: the cylinder of carbon, furnished with its ring, and immersed in the nitric acid of the vessel, fills the place of the electro-positive element, the cylinder of amalgamated zinc, in the sulphuric acid of the cell, that of the electro-negative element.

To unite several pairs into a battery, the cylinder of zinc is connected with the cylinder of carbon. This connexion is made by applying against each other the two slips or bent plates, which proceed from the upper edge of these cylinders, and maintaining them in close contact by means of a little copper clamp, furnished with a binding screw. It follows of course that the extremities, or poles of a battery, are represented on one side by the termination of a ring of zinc embracing the rim of the carbon (the electro-positive pole), and, on the other, by the termination of a cylinder of amalgamated zinc (the electro-negative pole.)

* This carbon is prepared by calcining,† with suitable precautions, in a sheet-iron mould, a well incorporated mixture of coke and rich pit-coal finely powdered.

† Vide Elec. Mag. p. 17.

Digitized by Google

A single pair has power to melt a thin iron wire, and can be advantageously employed in galvanoplastic and gilding experiments. The decomposition of water is obtained with two elements. The Academy may judge for themselves of the remarkable effects, obtained by means of a battery of forty pairs applied to the fusion of metals, the charcoal-light in vacuo, and the decomposition of water.

M. Bunsen has compared the intensity of the current of the carbon-battery with Grove's battery, as perfected by M. Poggendorff, by employing two apparatuses of equal dimensions; and he is hence led to conclude that the maximum of the current of Grove's battery, all things else being equal, is hardly three-hundredths superior to that of the carbon-battery: a difference, which amounts to nothing in practical applications. He has concluded, moreover, that the carbon-battery has the advantage of being more constant. To appreciate the constancy of feeble currents, in the carbon-battery, he employed a wire of some size for measuring the intensity of the current from hour to hour, and could not convince himself that there was the least diminution during four hours.

M. Bunsen has, moreover, made experiments relative to a mode of illumination, consisting of the flame produced by the current between two charcoal points. For this purpose he employed a battery of forty-eight pairs; the flame, by separating the charcoal points, could be lengthened to seven millim. ($\frac{1}{4}$ in.) M. Bunsen has measured the intensity of this light by means of a photometric apparatus of his own invention; and compares it to that produced by 572 stearine candles. The current, employed for this purpose, had an absolute intensity of 52·32. The expense for sustaining this light for an hour was, for the zinc, 0ᵏ·300; (10$\frac{1}{2}$ oz.) for the sulphuric acid 0ᵏ·456 (16 oz.) and for the nitric acid (of a density of 1·306), 0ᵏ·608. (21 oz.)

Although these data approach the truth as nearly as possible, M. Bunsen is not bold enough to infer from them that this mode of illumination may be easily put into practice on a large scale. This important question cannot receive a solution but by a series of practical experiments.

*Note by M. de la Rive.**—I have possessed, for more than a year, a combination like that of which Bunsen's battery consists, and I have had occasion to study its effect compared with that of other species of combinations, and especially the constant arrangement of Grove and Daniell. I

* Vide *Archives de l'Electricité*, April 1843, No. 7, p. 99.

Digitized by Google

will give, in the next number of the *Archives*, the result of this comparison, and I will add the description of a new kind of battery, which I presented, on the 6th of March, 1843, to the *Societé de Physique et d'Histoire Naturelle à Genève*, and of which I will say a few words at the end of the present number.*—[A.]

V. *Observations on the Battery presented by M. Reizet, at the Sitting of Feb.* 27, 1843. By M. BECQUEREL. From "Les Comptes Rendus," March 6, 1843, No. 10, p. 525.

(TRANSLATION.)

AT the last sitting of the Academy, M. Reizet presented a battery as being one of a new construction, and remarkable for its energetic effects. I ask permission of the Academy to lay before them a few observations on this apparatus, the physical and chemical effects of which are, it is true, some of the most striking; but which, nevertheless, has nothing novel in its construction beyond the substitution of coke for platinum to form the negative electrode.

This substitution is due to M. Bunsen, of Marbourg, who, instead of plates of platinum, has formed a cylinder of coke, such as to surround the zinc element. Each pair of this battery is composed of four cylindrical pieces, fitting one into the other. The exterior piece is a glass vessel filled with the nitric acid of commerce. In this vessel is placed the hollow cylinder of carbon, open at its two extremities, and having at its upper part, out of the acid, a ring of zinc well cleaned, at the border of which is a tongue of metal for forming contact with the zinc of the neighbouring pair. In the interior of the carbonic cylinder is placed another cylinder, composed of biscuit-ware or porous earth, closed at bottom, and about 1 millim. ($\frac{1}{24}$ in.) distant from the former; this cylinder, termed a *diaphragm*, is filled with water acidulated with sulphuric acid, in the proportion of one part acid of commerce to seven or eight of water. Finally, in this liquid is placed a cylinder of amalgamated zinc, terminated by a tongue for forming communication with the coke cylinder of the next pair. Forty pairs combined produce prodigious effects, of which the Academy has had the opportunity of being convinced.

* Vide Elec. Mag. p. 28.

Digitized by Google

On presenting the battery, M. Reizet announced that a single pair could be employed in galvanoplastic and gilding experiments. The author of this battery, M. Bunsen, comparing its action with a Grove's battery, found that the latter was scarcely $\frac{3}{100}$ more powerful in its effects than his.

I think I have not forgotten any of the principal conditions in the construction of the battery presented by M. Reizet. These then are my observations :—

The first constant battery which really merits the name, on account of the duration of its effects, consisted of, 1st, a glass vessel filled with concentrated nitric acid, in which was placed a cylinder of unglazed porcelain, containing in like manner a concentrated solution of potash ; in each of these liquids was placed a plate of platinum. From the moment contact was made between the two plates of platinum, the water and the nitric acid were decomposed with so much force, that a torrent of oxygen gas was disengaged around the platinum plate contained in the solution of potash. The electric current, the cause of so energetic an action, was due to the re-action of the acid on the alkali, in consequence of which the acid acquired positive, and the alkali negative electricity. This apparatus received at the time (it is about six years since I presented it to the Academy) the name of the oxygen-gas battery. I shewed the reasons on account of which these effects were constant. Batteries constructed with this element always presented one inconvenience. The nitrate of potash, in proportion as it crystallized in the pores of the diaphragm, by obstructing them, diminished the action of the battery, and terminated by stopping it entirely. I substituted moist clay for the porcelain cylinder, and employed U tubes of large diameter. I then obtained effects constant for several days ; but this battery presented a further inconvenience, which is also found in Mr. Grove's battery, and in that which has been presented to you ; it is that the nitric acid is decomposed in greater proportion as the action is more intense, so that there is a continual liberation of nitrous gas, which is very soon a source of inconvenience to the experimenters. To avoid this inconvenience, I substituted for nitric acid a saturated solution of sulphate of copper ; for the solution of potash, one of salt water ; and the separation between the two liquids was formed sometimes with a porcelain diaphragm, at other times with moist clay, or else with sail-cloth. In the sulphate of copper was immersed a copper plate, and in the salt water a plate of amalgamated zinc. Twelve elements only of this battery

Digitized by Google

produced the greatest effects of incandescence, fusion, and chemical decomposition,—effects, of which I have availed myself in making assays of gold ores.

Mr. Grove substituted for the solution of potash, one of water acidulated by sulphuric acid; and for the platinum plate, a plate of amalgamated zinc.

According to this statement, there is really but one novelty in M. Bunsen's battery; it is the employment of a cylinder of coke, instead of a plate of platinum; a substitution, however, which appears to me excellent. With regard to the effect, with equal surfaces, it must be the same; for the platinum, like the carbon, forms the non-oxidizable element.

There is one point to which I must call the attention of those who wish to employ this apparatus; it is the effects of endosmose, which take place between the two liquids by the intervention of the diaphragm of porous earth; and in consequence of which, as the liquids gradually mix, a point is attained, at which the current ceases to be constant. In this battery, the current is due to two causes: 1st, to the action of the water, acidulated by sulphuric acid, on the zinc,—this metal acquiring negative electricity, and the acidulated water, positive; 2nd, to the mutual reaction of the two solutions, in consequence of which the nitric acid acquires positive electricity. These two causes uniting, give more energy to the pile.

Precisely this condition it is that I have always fulfilled in my arrangements.

Hence, it is of importance to create all possible obstacles to prevent the mixture of the two liquids, without detracting from the intensity of the current.

The following is the result of an experiment I made for determining the quickness of the endosmose between two liquids,—sulphuric acid, diluted in the proportions indicated above, and nitric acid of commerce, separated by a diaphragm of baked earth.

In a glass vessel I placed 144 grammes* of distilled water, and 19 grammes of anhydrous sulphuric acid. In this liquid I immersed a cylinder of unglazed porcelain, 3 or 4 millimetres ($\frac{1}{9}$ or $\frac{1}{8}$ in.) thick, containing 95 grammes of nitric acid, and I allowed the endosmose to go on for forty-eight hours. I then sought for the quantity of sulphuric acid passed into the nitric acid, and found there were 3·5 grammes,—almost the sixth part of the sulphuric acid which was contained in the acidulated water. Into the latter had passed a propor-

* Gramme = 15·444 grs. Eng.—Ed.

Digitized by Google

tionate quantity of nitric acid; for there is never endosmose without exosmose. This acid, by going to the other side, must increase the reaction of the acidulated water on the zinc, and even attack the mercury.

From the observations I have now offered, it is plain that M. Bunsen's battery only differs from the constant batteries, known to the Academy, inasmuch as for the plate of platinum immersed in the acid, is substituted a cylinder of coke, which is much less expensive; and the diaphragms are nearer; but there is reason to doubt whether, on account of the release of nitrous gas, they will be preferred in the arts to the batteries now generally in use, which, when composed of only twelve pairs of large surface, instead of forty, produce the greatest physical and chemical effects, without there being any fear from the deleterious effects of nitrous vapours.*—[A.]

VI. *Note on a new Voltaic Combination.* By M. le Professeur A. DE LA RIVE. (Communicated to La Société de Physique et d'Histoire Naturelle de Genève, 16th March, 1843.) From "Archives de l'Electricité," April 5th, 1843, No. 7, p. 112.

(TRANSLATION.)

IN consequence of some researches, which I shall publish in the next number of the "Archives of Electricity," I was led to find that peroxide of lead may advantageously supply the place of nitric acid in Grove's battery. For the present I shall confine myself to saying a few words on this subject, reserving the details for the memoir to which I have just alluded.

After having placed a thin sheet of platinum in the interior of one of the porous cells, employed in Grove's battery, I surrounded the platinum with powder of peroxide of lead well rammed; it is of importance that the ramming be as firm as possible, a delicate operation, seeing that there is a risk of breaking the porous pipe-clay cell. I afterwards, by means of a clamp, fix a copper conductor to the upper edge of the plate of platinum, which emerges from the peroxide; I then immerse the porous cell, thus filled with peroxide of lead, into a vessel, filled with diluted sulphuric acid, into

* We have, at the lecture table, employed Grove's batteries with perfect impunity, having them enclosed in a wooden box, according to the plan first adopted by Mr. Gassiot.—ED.

Digitized by Google

which has been previously placed the plate of amalgamated zinc, also furnished with its conductor. The acidulated water, which I employ, contains one-tenth, and sometimes only one-twentieth in volume of acid. To complete the description, I may add that the porous cell, which I employed, was 4 in. square; and consequently presented two equal surfaces, each of 16 sq. in. The amalgamated zinc presented a double surface, as in the ordinary pairs of Grove's battery; but the surface may be less without inconvenience.

The pair, of which I have just given the description, presents the important property of being able to decompose, with great facility, water, acidulated with sulphuric acid, even when the two electrodes are of platinum. Of course the gases are obtained perfectly separate. I have commonly obtained two or three cubic centimetres* of mixed gas per minute; sometimes I have had as many as five, and even nine cubic centimetres. The water was distilled water, mixed with one-seventh or one-tenth its volume of very pure sulphuric acid.

The platinum electrodes, by which the current of this single pair is conducted into the acidulated water, become very speedily polarised; so that, at the end of a few moments, the current is weakened; but it does not cease from decomposing in a very constant and regular manner, except that in lieu of five or of three cubic centims. per minute, it finishes by not giving more than one or two per minute. To restore to the current all its chemical activity, we have only to change the direction of the current in the voltameter, so that the electrodes change their functions; immediately the decomposition attains its high power.

It may not be out of place to remark, that one pair of Grove's, in which the place of the peroxide of lead is supplied by nitric acid, produces, under similar circumstances, a decomposition of acidulated water, which is scarcely sensible; and that this decomposition is nothing with one pair of Daniell's, or with every other kind of combination.

With respect to the calorific effects of the pair of peroxide of lead and amalgamated zinc, they are quite as energetic as those of a similar pair of Groves, if not more so.

I obtained a temperature of 450°, by making the current of the pair pass through the helix of Breguet's thermometer; the current of the same pair, in which I had substituted, for the porous cell filled with peroxide of lead, a cell filled with nitric acid at 40°, which had not been used before, gave, under the same circumstances, 425°. I only obtained 45°,

* About 16 cub. cen =1 cub. in.—Ed.

Digitized by Google

when the nitric acid in the cell was changed for sulphuric acid, similar to that in which the amalgamated zinc was contained.

I will not now dilate further on the properties of this new kind of pair. I will simply remark, that it possesses the advantage of requiring the employment of only one kind of liquid—sulphuric acid diluted with water; that there is not the inconvenience, as in Grove's batteries, of disengaging disagreeable vapours, such as the nitrous vapours; and that, above all, it offers the remarkable property of decomposing water, a decomposition which requires, with all other voltaic combinations, the employment of at least two pairs arranged in series.

I have also arranged in series several pairs of peroxide of lead and amalgamated zinc. Three pairs give considerable chemical, calorific and luminous effects, quite as intense as those obtained with three pairs of Grove's of the same dimensions. But the effects of the latter are more constant; this arises from the facility with which the pairs are polarised, where peroxide of lead and a single liquid are employed.

A very advantageous combination is the union in series of one pair of Grove's, or of Daniell's, and one pair of the peroxide of lead and amalgamated zinc. A battery thus formed is more energetic than that resulting from placing in series two pairs of Grove's, or two of the peroxide of lead.

I shall return, I say, to these points; for the present I confine myself to repeating that it is especially as a single pair that the new voltaic combination, which is the object of this note, appears to me to be remarkable, and worthy of being recommended to the attention of philosophers.—[A.]

VII. *On the Chemical Action of a single Voltaic Pair, and the Means of augmenting its Power.* By M. A. DE LA RIVE, of Geneva. From "Les Comptes Rendus," April 17, 1843, No. 16, p. 772.

(TRANSLATION.)

A PLATE of zinc and one of platinum, are placed, without being in contact, on the same conducting liquid; the two plates are united, exterior to the liquid, by a wire; a current is immediately established in the circuit thus formed;

Digitized by Google

this current has the power of producing exalted calorific and magnetic effects.

But if this wire, which unites exteriorly the two plates of the pair, is interrupted by the intervention of a liquid conductor, and if the portions of the wire, which communicate with the liquid are platinum, the current either entirely ceases to pass, or else passes very badly. At all times, a sensitive galvanometer, placed in the circuit, indicates, even under these circumstances, the passage of a slight current; and the property, acquired by the platinum wires, which were used for including the liquid in the circuit, of giving rise themselves to a secondary current, seems to demonstrate, that there has been an electro-chemical decomposition, although, as far as we could judge, this decomposition is not sensible.

Many philosophers, first M. Becquérel, sen., and he long before all others; then MM. Henrici, Martens, Grove, Schoenbein, and Edmund Becquérel, have sought to study the effect of the passage of the current, produced by a single pair through a liquid conductor. They have succeeded in effecting this transmission, by substituting, for one at least of the platinum electrodes, an electrode of another nature, or else spongy platinum; but they have not specially directed their attention to the means of transmitting the current, when both the electrodes are platinum plates or wires. This case it is, which I have desired to investigate more closely, employing, as a liquid, distilled water mixed with a proportion of sulphuric acid of about $\frac{1}{10}$ in volume.

A single cell of the constant battery, excited with sulphate of copper and salt-water, and having a wooden diaphragm, did not sensibly decompose the water, although the electrodes were very close (only one centimetre apart,) and each presented a surface of at least sixteen sq. centimetres. A galvanometer, that was not very delicate, when placed in the circuit during the first moments, gave a deflection of 20° to 25°, and settled at a permanent deflection of 5° or 6°; and, after interrupting the circuit, the electrodes produced a secondary current of nearly 90°. A very energetic commencement of chemical decomposition had evidently taken place; this decomposition then diminished and became insensible. Presuming that the adhesion of the liberated gases on the surface of the platinum electrodes might be the cause of this diminution, I placed the apparatus, in which the decomposition was taking place, beneath a bell-glass, in which a vacuum could be made. As soon as I had made the vacuum, some very fine bubbles of gas escaped from the surface of the platinum, and the galvanometer gave a deviation of 10° or 12°, which proved

Digitized by Google

that the current had at least doubled in intensity. Soon, however, the galvanometer fell again to 5° or 6°; and several fresh strokes of the piston were required to bring it again to 10° or 12°. The gases adhere so firmly to the surface of the platinum, that, even in the best vacuo, they do not completely quit the surfaces; nevertheless, the experiment proves that they do partially escape, and render the transmission of the current easier. This is especially true, in respect of hydrogen; for the adhesion of oxygen to the platinum is a true chemical combination, as I have already had occasion to mention elsewhere,—an observation confirmed by other facts, which will be entered into in the sequel. The adhesion of hydrogen to the platinum electrode made me presume that to the adhesion of this gas might, in like manner, be attributed the almost complete absence of chemical action, presented by a plate of amalgamated zinc, or a plate of cadmium, when isolated and immersed in diluted sulphuric acid. Now, chemical action does take place at the first moment of the immersion; but the liberated bubbles of hydrogen form a thin layer, adhering to the surface of the metals, which protects this surface against any further chemical action. To prove that this is the state of things, I placed under the receiver of an air-pump, in one case, a piece of amalgamated zinc, in another case a piece of cadmium, immersed in distilled water, containing $\frac{1}{20}$ in volume of sulphuric acid. As soon as the vacuum was obtained, bubbles were abundantly liberated from the surface of either metal, and a very energetic chemical action took place. Immediately on the air being returned, the bubbles of gas, still adhering to the surface of the metals, flattened out, the metallic surface assumed a dead appearance (which was due to the layer of gas), and the chemical action entirely ceased, or lost much of its energy. Two plates of cadmium, having been immersed in acidulated water, the one in vacuo and the other in the air, the former lost, in the space of twenty-four hours, eight, and the latter only three, centigrammes; they had each weighed twenty grammes, and presented a similar amount of surface to the chemical action of the liquid. Thus the atmospheric pressure, by facilitating the adhesion of hydrogen to the metallic surfaces, may be an obstacle to the continuation of certain chemical actions, which only take place at the first moments. This point of view may perhaps be interesting to follow out in other cases of chemical action.

Convinced, by the preceding experiments, that the true obstacle to the transmission of the current of one pair through a liquid conductor is the formation of the primary gaseous

Digitized by Google

layers on the surface of the electrodes, I sought means to get rid of this obstacle by removing these layers. The true means is to liberate, on each electrode, oxygen and hydrogen alternatively. With this view, I constructed an electrepeter, which, when introduced in the circuit, reverses the current, and directs it alternately in contrary directions. The current of a single pair is immediately transmitted through the liquid conductor; and the platinum electrodes, at the end of a certain time, are covered with a layer of finely-divided platinum, which always occurs with currents directed alternately in contrary directions. I employed, in these experiments, a small pair, consisting of platinum and cadmium; the plate of cadmium exposed a surface of six square centimetres; that of platinum double the surface. The two plates were immersed in a vessel, containing ninety cubic centimetres of acidulated water. The current was at first transmitted through a very fine platinum wire, placed in the centre of a platinum capsule, containing four grammes of distilled water. The hydrogen gas, liberated on the platinum plate of the pair, was collected; first of all, I assured myself that, for a given quantity of gas liberated on the platinum of the pair, and hence for a given quantity of electricity produced, the elevation of the temperature of the water, in which the platinum wire was immersed, was the same, whether the current was continued or alternate. A voltameter was then included in the circuit:*—the current did not pass at all, while it was continuous, but, as soon as it was rendered alternate, by bringing the electrepeter into action, it was easily transmitted. This was very speedily perceived; for there was a liberation of hydrogen at the platinum of the pair, and the temperature of the liquid in the voltameter became sensibly raised, as did that also of the pair itself. There were ten cubic centimetres of hydrogen gas liberated in 15′, on the surface of the platinum of the pair; the temperature was raised from 13° to 15°; the liquid of the voltameter was exactly the same as that of the pair, and there was the same quantity of it: the elevation of the temperature of this liquid was in like manner, 2°; but there was no liberation of gas on the plates, seeing that the currents were alternate, and the plates of platinum presented a sufficiently large surface for contact with the liquid.

The same results are obtained with any pair. Nothing more is necessary than to interpose in the circuit, which already includes a voltameter, a delicate calorific galvano-

* I apply this term, as Faraday proposed, to a vessel filled with acidulated water, in which are contained two platinum wires or plates, which serve to transmit the current, employed for the decomposition of the water.

Digitized by Google

meter, such as the helix of a Breguet's thermometer, or a platinum wire passing through the globe of a thermoscope. So long as the current is continuous, the instrument does not become heated; but, as soon as it becomes alternate, the instrument indicates an elevation of temperature of many degrees, which is due to the passage of the current.

Instead of employing an electrepeter, the currents may be directed through the liquid of the voltameter, alternately in contrary directions, by means of an electro-magnet. For this purpose, the apparatus is so arranged that the liquid shall be traversed alternately by the current of the pair, and by one of the currents of induction, determined in the metal wire surrounding the soft iron, and the current of the pair itself [*i. e.* the primary wire current]. These two currents are determined in contrary directions:—during the first moments of the experiment, the current of induction is superior to the current of the pair; thus there is a disengagement of gas on the platinum electrodes; but, at the end of a longer or shorter period, the electrodes become black, and there is no longer a liberation of gas, which proves that the current of the pair traverses the liquid, as easily as the current of induction. In this manner, the current of induction favours this transmission, by constantly carrying oxygen to the electrode at which the current of the pair must liberate hydrogen, and hydrogen to the electrode at which the current of the pair must liberate oxygen. Mr. Grove had previously observed an effect of this kind by a different process.

In the preceding experiment, there are two currents traversing the liquid alternately in different directions; the current of the pair itself, and the current of induction, which is due indeed to the same current of the pair. Now, a remarkable circumstance occurs here,—if the surface of the electrodes is small, the current of induction is the superior; if large, the current of the pair is: there is a certain limit, within which both the currents are equal. This limit is obtained by the two platinum plates, by means of the black powder with which they become covered, and which tends to increase their surface of contact with the liquid, by exactly a sufficient quantity. A galvanometer, placed in the circuit, shows very well all the phases of the relative intensity of the two currents.

When these plates or the platinum wires, which have served as electrodes, have acquired a pulverulent surface by means of the alternate currents, they become, like spongy platinum, capable of transmitting through a liquid conductor the current of a single pair, and this liquid is decomposed. But

Digitized by Google

hydrogen alone is liberated in a manner distinctly evident; the oxygen appears to be absorbed by the electrode. The pair I employed for these experiments was one of Daniell's constant cells.

When we examine closely the resistances which the current of a single pair has to overcome, in order to traverse a circuit, in which is interposed a voltameter with platinum electrodes, we feel no surprise at the almost impossibility which exists to its traversing it. In fact, in a pair of amalgamated zinc and platinum, contained in diluted sulphuric acid, the current, setting out from the zinc, must pass along the liquid of the pair, penetrate into the platinum of the pair, where it deposites the hydrogen, then pass through the liquid of the voltameter, depositing equivalents of each gas on either platinum electrode. The resistance is essentially manifested at the three parts of the circuit, where the current must pass from the liquid into the platinum, or from the platinum into the liquid. It has appeared to me that if we succeeded in diminishing one at least of these three resistances, much would be thereby gained; and that, in order to have the decomposition of the water in the galvanometer complete, we ought to diminish the resistance, which takes place at the platinum of the pair. Mr. Grove has already obtained, with respect to this, an important result, by immersing the platinum, not in the acidulated water, in which the zinc is placed, but in nitric acid of 40°, which is itself separated from the acidulated water by a porous diaphragm of unglazed porcelain. The hydrogen, with which the current tends to cover the surface of the platinum of the pair, is absorbed by the nitric acid; the resistance is consequently much diminished, and the water in the voltameter is slightly decomposed. M. Becquérel, sen., tells me of his having also observed that water may be decomposed by substituting a plate of zinc in his nitric acid and potash battery, for the platinum plate, which is contained in the potash, and transmitting through an ordinary voltameter the current of this simple battery.

I have endeavoured to substitute a peroxide in powder for the nitric acid. In this I saw two advantages: first, to diminish the resistance, as is the case with the nitric acid; secondly, to obtain a current, by the reduction of the peroxide, — a current, the direction of which, like that of the current derived from the oxidation of the zinc, should augment considerably the electro-chemical power of the pair. There was moreover a practical advantage in the substitution of a per-

Digitized by Google

oxide for the nitric acid,—this was, that hence we require only one liquid to excite the pair.

My experiments have been made on the peroxide of manganese and the peroxide of lead. The latter has a very decided superiority. The peroxide, reduced to a state of fine dry powder, is rammed with care into a porous tube of unglazed porcelain; a plate of platinum is placed in the middle of the cell, so as to be completely surrounded by the peroxide. This plate is furnished with a connecting piece, to which a copper conductor is attached. The liquid, in which the porous cell containing the peroxide of lead, and the amalgamated zinc are placed, may either be salt water or sulphuric acid diluted to a greater or less degree with water.

With peroxide of manganese, I only obtained 2 cub. centimetres of gas per minute, and the effect was soon reduced. With peroxide of lead I obtained as much as 10 cub. cent. of gas per minute with the same voltameter, and the effect did not cease, but only became slightly reduced. A method of restoring to it all its energy is to change the direction of the current in the voltameter. The polarization of the platinum electrodes, which is the cause of the apparent diminution in the intensity of the current, is thus destroyed.

Under like circumstances, one pair of Grove's only gives rise to a decomposition scarcely sensible. The difference is much less with respect to the calorific effects. One pair of Grove's produced 420° in a Breguet's helix; a perfectly similar pair, but in which peroxide of lead was used instead of nitric acid, produced 450°. Different comparative experiments, made with a Bunsen's pair, (a Grove's pair, in which carbon is employed in place of platinum,*) and one of Daniell's, have all demonstrated the decided superiority of a peroxide of lead pair, especially for chemical effects. These effects, with other pairs, are either nothing or almost insensible.

The duration of the action with the peroxide of lead pair is considerable, providing care is taken to depolarize the electrodes occasionally. This pair is very convenient in practice, because it only requires the use of one liquid, which is easily obtained, viz., salt water, or diluted sulphuric acid. I also conceive, that both in this respect and in respect of economy, it may be advantageously used in the applications of electricity to gilding, plating, and the metallurgic arts in general, instead of batteries of several pairs, which are always more expensive and complicated. The experiments which I have made on this point have been very satisfactory.

* Vide Elec. Mag. p. 16.

Digitized by Google

The superiority of peroxide of lead pairs is not maintained, when many are placed in series. A single pair produced 14° in a calorific galvanometer, formed of a platinum wire 12 centimetres long, and $\frac{1}{2}$ millimetre in diameter, along which the current passed. Two pairs in series produced 18° in the same galvanometer, and 24 cub. centimetres of gas per minute. Two of Grove's pairs, under the same circumstances, produced 19° in the calorific galvanometer, and 27 cub. centimetres of gas per minute. But, which is very curious, a battery formed of one of Grove's nitric acid pairs, and one of the peroxide pairs, produced effects superior to those obtained either with a battery of two of Grove's, or one with two of the peroxide of lead. It produced 24° in the galvanometer, in place of 18°, and 32 cub. cent. of gas per minute in the voltameter, instead of 24 or 27. This superiority is doubtless due to the mutual chemical action of the current of each pair on the other pair. A powerful effect is also obtained by forming a battery with one pair of peroxide of lead and one of Daniell's sulphate of copper. In this case 31 cub. cent. of gas are obtained, whilst two of Daniell's pairs only give 10 or 12 cub. cent., and two of the peroxide of lead, 24 cub. cent.

A battery of three peroxide of lead pairs gives 72 cub. cent. of gas per minute; it ignites to red-heat the platinum wire of the calorific galvanometer, and, in fine, gives a brilliant light with the charcoal points. But, when employed in series, the peroxide of lead pairs have not a very constant power; a deposition of oxide of zinc occurs on the sides of the porous cells, which must occasionally be removed.

A copper plate, substituted for the platinum plate, in pairs of the peroxides of lead or manganese, renders them incapable of producing any chemical action, and very decidedly reduces their calorific effects. This effect is probably connected with a local electro-chemical action that takes place at the surface of the copper-plate, which latter is indeed rapidly altered.

From the preceding observations it seems to follow that, in order that a pair may produce a chemical effect, such, for example, as to decompose water with platinum electrodes, there must be in the pair two chemical actions giving rise to two currents, the effects of which are united, the oxidation of zinc, and the reduction of a peroxide. If water is not decomposed by one of Daniell's pairs, or is so in a manner scarcely sensible by one of Grove's, it is, because the reduction of the oxide of copper in the former, and the deoxidation of the nitric acid in the latter, take place but slightly or not

Digitized by Google

at all. Hence it is that, as soon as a similar pair is added to either of these two pairs, the current of the new pair, by traversing the former, augments the oxidation of its zinc, facilitates the reduction of the oxide of copper, or the deoxidation of the nitric acid, and thus enormously increases the current of the former pair. The current of the first pair produces a similar effect on the second. And thus, the effect of two constant pairs, placed in sequence, is infinitely greater than the effect of one alone; and that which is true of two pairs, is true of three or of a higher number. The limit in the increase of effect does not occur until, by the increase of the number of pairs, the resistance of the battery becomes greater than that of the interposed conductor.

This observation led me to enquire if, instead of employing the current of a second pair to increase that of the first, we could not employ the current itself of a pair to increase its own intensity. After various attempts, I succeeded in realizing this conception, by means of a very simple apparatus, which I propose naming *the electro-chemical condenser*, or rather *the voltaic condenser*.

The principle of this apparatus consists in employing the current of a constant pair, which is to effect the decomposition, to produce at the same time a current of induction through the pair itself, in such a direction as that its effect should be of a nature to oxidize the zinc, and deoxidize the sulphate of copper or the nitric acid. This current thus produces on the pair the same effect as that which the current of another pair would produce. The arrangement of the apparatus is by no means complicated. It is a piece of soft iron, surrounded by thick wire covered with silk; the current of the pair traverses this wire, and magnetizes the piece of iron: immediately, a little moveable piece of copper, which is furnished with a piece of iron that is attached by the magnetized iron, is raised so as to break the circuit; there is then developed in the wire a current of induction, which traverses the pair, and which, united with that of the pair itself, that it has thus reinforced, passes through the voltameter, included in the circuit, and decomposes the water. But the soft iron, being no longer magnetized, the piece of copper falls back, the metallic circuit is again formed, the iron is again magnetized, and the same effect is renewed. By means of this apparatus, one pair of Grove's which decomposes water very slightly, and one pair of Daniell's which does not sensibly decompose it, become capable of decomposing it with great energy. From ten to fifteen cubic cent. of gas may be obtained per minute. One pair of peroxide of lead, which gave nine cubic cent. of gas per minute, immediately on the inter-

Digitized by Google

position of the apparatus in the circuit, gave eighteen cub. cent. This same pair also gave, under these circumstances, a powerful light with the charcoal points.

The gases derived from the decomposition are by no means mixed by the interposition of the *voltaic condenser* in the circuit, the induced current being always determined in the same direction as that of the pair. These gases may be collected separately with the greatest facility, and are found to be in the exact proportion which constitutes water. This simple and inexpensive apparatus, may also be advantageously employed in metallurgic applications. Its interposition in the circuit of a pair produces the same effect as that which would be produced by the addition of one or more pairs, without occasioning the same expense.

I may add that I have not succeeded in obtaining, by the employment of the voltaic condenser, a decomposition of water, by using a simple pair of zinc and platinum placed in salt or acid water. Two chemical actions must necessarily be in operation in the pair, or have the power of being in operation, in order that the water may be decomposed, even when this voltaic condenser is used. On that account it is, that it is necessary to use either a pair with two liquids, like those of Daniell and Grove, or a pair in which the negative metal is replaced [? surrounded] by a highly oxidized body, as the peroxide pairs, of which I have spoken above.

I ought to add, that, in order that the condensing apparatus shall act well, the wire coated with silk, which surrounds the piece of soft iron, should be of large diameter and of a moderate length. In the apparatus that I have used there were three copper wires, one millimetre in diameter, each making 100 convolutions, and united at their corresponding extremities, so as to represent a single wire, three millimetres in diameter, with 100 convolutions.

To sum up, I think I have succeeded in establishing, in the preceding notice, that a single pair may produce chemical effects, and even powerful chemical effects.

I have proved it :—

1st. By shewing that in vacuo, where the adhesion of the gases to the surfaces of the electrode is less, the current is much more readily transmitted.

2nd. By shewing that the current of a single pair, rendered alternate by the employment of an electrepeter, very easily traverses a voltameter, having platinum plates, and charged with acidulated water.

3rd. By shewing that the same occurs with the direct current of a battery, when it is transmitted through a voltameter, which is at the same time traversed by a current of

Digitized by Google

induction, determined in a direction contrary to that of the pair.

4th. By constructing a pair in which the platinum is replaced [? surrounded] by a peroxide, and especially by the peroxide of lead, which renders this pair, even though it is charged with but one liquid, acidulated or salt water, capable of decomposing water with very great energy, at the same time giving the gases separate.

5th. By employing the current of the pair itself to produce an induced current, which, by traversing the pair in a proper direction, increases its electro-chemical power to such an extent, that this power, almost nothing or very feeble, becomes equal to that of a battery of many pairs.

I hope that, independently of a scientific point of view, the researches, which I have just communicated to the Academy, may present some interest in a practical point of view, by permitting, in very many cases, a single pair to be employed in place of a battery,—a substitution equally advantageous in respect of economy, and facility of manipulation.—[A.]

VIII. *Remarks, in consequence of a recent communication from M. de la Rive.** By M. Bouquillon. From "Les Comptes Rendus," May 15, 1843, No. 19, p. 1089.

(TRANSLATION.)

The following paragraph will be found, in the Memoir read by M. de la Rive to the Academy of Sciences, in the sitting of April 17, 1843 (Comptes Rendus,) vol. xvi. p. 780.

"... I have not succeeded in obtaining, by the employment of the voltaic condenser, a decomposition of water, by using a simple pair of zinc and platinum, placed in salt or acid water. Two chemical actions must necessarily be in operation in the pair, or have the power of being in operation, in order that the water may be decomposed, even when the voltaic condenser is used. On that account it is that it is necessary to use either a pair with two liquids, like those of Daniell and Grove, or a pair in which the negative metal is replaced [? surrounded] by a body highly oxidized, as the peroxide pairs, of which I have spoken above."

In the small number of experiments which I have been able to make, since I have procured M. de la Rive's Voltaic

* Vide Elec. Mag. p. 30.

Digitized by Google

Condenser, I have determined that the decomposition of water is easily obtained by one of the pairs described in the note, that I presented to the Academy of Sciences, the 23rd of last September, and which only require the use of a single liquid. These pairs are nothing more than an economical modification of Smee's arrangement, who, since 1840, has proved that a finely divided layer of platinum, covering the surface of the negative element of a voltaic pair, favours the disengagement of hydrogen, the adherence of which to the polished surface of platinum considerably weakens, if it does not entirely stop, the development of the electric current.

I may add that, in the first of these experiments some hours sufficed to dissolve completely the positive platinum electrode of my voltameter; which, like the single pair that I used, contained only water, acidulated with the sulphuric acid of commerce.

This last phenomenon is perhaps due only to the presence in that acid of a certain quantity of hydro-chloric acid, a circumstance which time has not, as yet, permitted me to verify.—[T.]

IX. *On a New Process for producing, by means of Electricity, Pictures analogous to those of Möser.* Letters from M. A. Morren to M. Arago. From "Les Comptes Rendus," May 15, 1843. No. 19, p. 1098.

(TRANSLATION.)

Rennes, May 2.

I read, in the "Comptes Rendus" of the sitting of the 10th of last April, a note from Professor Masson on the pictures produced by electricity, and on the hope conceived by this philosopher, of arriving, by the experiment he quotes, to the explanation of the curious phenomena observed by M. Möser.

I have repeated M. Masson's experiment without being able to succeed in obtaining satisfactory pictures; perhaps my want of success may be due to the very precautions I have taken. I am about to describe to you a different process for producing with facility, simplicity of means, and, I I may say, almost perfection, pictures of medals, &c., by means of electricity.

If a little very fine dust, well-powdered tripoli, for example, be thrown upon a dry and clean medal, and be spread with

Digitized by Google

the finger, so that it may lodge in all the parts protected by the reliefs, if it is rubbed very lightly with a little cotton, and if, after having inverted it, to shake off any slight excess of dust, the medal is placed on an isolating substance, as, for instance, a cake of rosin; if then a small stick of lac or sealing-wax, well electrized be brought above it, the light bodies which accumulate in the parts around the reliefs are driven normally to the surface of the medal, and so trace out a perfect picture of it on the cake. To obtain the impression on a conducting substance, as, for instance, a metal, a polished stone, &c., it is only necessary to place three little drops of lac at three points in the circumference of the object to be copied, so as to leave between it and the conducting plate a very thin film of air. The picture obtained will be quite as faithful. By the simple action of electric repulsion, I have succeeded in copying medals, and engraved plates. We must be guided in the choice of the colour of the dust, by the colour of the body on which the impression is to occur.

With respect to M. Masson's pictures, I have succeeded in producing them only as often as I left on the medal a little dust, either of red-lead, sulphur, &c. After perfectly cleaning the object to be copied, I could not obtain anything, either by a feeble, or by a high degree of electric tension.

If, as I think, M. Masson's pictures bear any analogy to those, which I have the honour of communicating to you, neither one nor the other, produced as they are by a simple effect of electric repulsion, appears to me capable of throwing any light toward the explanation of the phenomena described by MM. Möser, Karsten, and Knorr.

Rennes, May 7.

Since the letter, dated May 2, which I had the honour of writing to you, I have been engaged in repeating the experiments of M. Karsten.

Annoyed by the uncertainty and failure which often exist in the production of the pictures, that ought to be formed on a plate of glass by an electric spark falling on a medal properly placed, I sought for the cause whereby these experiments were rendered uncertain, and I arrived at the following result:—that, in order to obtain these impressions with certainty and accuracy, it is necessary that the medal be covered with an extremely thin layer of moisture; if the medal is wiped with fine linen or with silk, the moisture is not removed from the parts protected by the reliefs, and the electricity then acts on this fine layer exactly as it acts on the

Digitized by Google

very fine dust lodged in the same insterstices, as I had the honour of pointing out to you in my preceding letter; only, in the case of M. Karsten's pictures, the glass must be exposed to a puff of moist breath to perceive the modifications produced on its surface.

To repeat, pictures may be produced, by means of electricity either on a plate of glass, or on a conducting body, (in the latter case a thin film of air must be interposed between the medal and the body to receive the impression.)

These pictures are obtained, by placing in the hollow parts of the medal, either very fine dust, or a very slight film of moisture (that of the fingers is often sufficient); then, after having lightly wiped it, the medal is to be placed on a plate of glass, and either an electrized rod of lac, or the knob of a Leyden jar is to be brought near it; only, in the latter case, in order to obtain a very distinct picture, care must be taken to place the medal so far away from the edges of the glass plate that the discharge of the jar may be incomplete. Immediately,—and a little skill produces it in great perfection,—the picture is perfectly visible, if the experiment is made with light bodies, as tripoli, &c.; in the case of Karsten's pictures, the moisture of the breath must be slightly applied to the plate.

When either one of these pictures is produced, if the plate is reversed over another plate of glass, and the knob of a Leyden jar is applied, the image is also transferred to the new plate.

The explanation of the production of these impressions is easy, and seems to me quite different from that which some philosophers are disposed to assign; it is nothing more than a simple effect of electric repulsion.—[A.]

X. *A new Method of exciting Electricity with the Gun: and Proposition for Artificial Lightning.* Letter of Dr. Ferdinando Elice, Professor in the Royal University of Genoa, and Associate of many Scientific Academies. Communicated by M. Dentone.

(TRANSLATION.)

My very dear Friend,—I am about to offer you a few new experiments upon electricity which I made some days ago; I trust they may be as gratifying to you as those, in which

Digitized by Google

you participated last year, upon the electric spark, obtained from coffee,* and by other means; and as those also upon gunpowder, which produced the electric spark without being inflamed. I found that electricity could be easily excited with the gun: and in the following manner. I insulated, with a silk thread, a disc of copper of the diameter of three decimetres (1 ft.), and connected it, by means of a brass wire, with a Volta's electroscope; I then fired the gun against this disc, from the distance of about half a metre (20 in.); and I immediately observed the electroscope positively electrified. The gun was loaded with about a gramme (15½ grs.) of powder without wadding; the weather was cold and dry. I repeated the experiment, with certain variations; instead of using the electroscope, I employed only the collecting plate of the condenser, which I insulated with a silk cord; and, having fired at the brass disc the same quantity of powder as at first, on approaching the finger towards the collecting plate, I clearly saw the electric spark. I repeated these experiments several times. Sometimes with the same disc, and sometimes by substituting discs of pewter, tin, glass, resin, wood, paper, and cardboard, &c., of the same size; occasionally, again, in lieu of the discs, I employed a little silk, or woollen cloth, or leather, or a sponge, or a lump of cotton, in circles of about the same dimensions as the discs; and always with more or less success. That which especially invites observation is this, that all the bodies mentioned will be always positively electrized; not excepting the resin itself; and that the insulators will lose the electricity almost in an instant, as will also the conductors, although they be insulated.

Wishing to know if, in the above mentioned experiments, the gun was electrified, and with what species of electricity, I insulated it with silk cords; and, when loaded, I placed it in communication with the electroscope; when ready, I fired; and, after three ineffectual attempts, I saw the gold leaves of the electroscope diverge a very little. I repeated these experiments fifteen times, and twice only did I observe the said leaves diverge a little.

In making these experiments, I would have adopted a gun with a larger bore (for the mouth of the one I employed was only twelve millimetres (½ in.) in diameter), augmented the quantity of gunpowder, and used wadding; I would have placed in it other powders, or pieces of various substances, sometimes insulators, sometimes conductors; also both kinds

* Vide Proceed. Elec. Soc. p. 288.

Digitized by Google

mixed together; and would have fired at various distances, and in different places, sometimes open, at other times confined, &c. But the want of the requisite convenience and shelter, near my residence, prevented me.

I hope, in a little time, to be more at ease in my country excursions so as to enable my experimenting on all that can be wished. I would, moreover, make an experiment on a large scale, taking a large charge of gunpowder, and, instead of employing one, would employ many guns or cannons, and proportionately augment the number and size of the discs, &c.; in these cases, one might develope a very great quantity of electricity, capable of forming an artificial lightning.

I must not omit to inform you, that the electricity may be obtained with an air-gun. I sometimes stopped it with paper, sometimes with cotton or tow; at other times with both these substances, or with the three; and I had discs (of the diameter of two decimetres (8 in.) of brass, of wood, a rabbit skin, &c.), at which I directed the discharge:—the electricity was positive. I must also tell you that several times, on the same and on other days, I burned upon the cap of the electroscope, one or two grammes, and sometimes a larger charge of gunpowder; but I never had the least sign of electricity.

I am sorry I am not able just now to make any observations upon several particulars connected with the above and other experiments; but these will form matter for one or two letters, in which I shall study to give you the explanation.

In the mean time accept the sentiments of friendship, with which I am, your very affectionate—Ferdinando Elice.

[B].

XI. *On Animal Electricity.* By M. Ch. Matteucci. (Extracted from a Letter from the author to M. de Blainville). From "Les Comptes Rendus," 24th April, 1843, No. 17. p. 930.

(translation.)

The particular object of the first part of this memoir is to establish, by a great number of very varied experiments, the similarity that I had already perceived and noticed in my preceding labours, between the function of the electric organs of the torpedo and muscular contraction.

I shall commence by showing this parallelism in the action of the electric current. I shall state in a few words the laws

Digitized by Google

of the action of the electric current on the motive nerves. In the first period of the vitality of the nerve, the electric current, which acts on it, excites muscular contraction, either at the moment that it enters, or at the moment that it ceases; and this, whatever its direction relative to the ramification of the nerve may be. In the second period of the vitality of the nerve, the contraction is only excited by the direct current which commences, and by the inverse current which ceases.

I have subjected the nerves of the electric organ, quickly separated from a live torpedo, to the action of the electric current. This action, as I have already proved, excites the ordinary discharge of the organ. To discover and study the discharge thus excited, some recently prepared frogs must be placed on the organ, and be touched at the same time in both surfaces with the plates of the galvanometer. In order that this experiment may be done with care and without the least fear of erroneous results, I will explain my manner of operating. I employ, to obtain the current, a Faraday's battery of fifteen pairs, which I place on an insulated stool. I separate quickly one of the organs of a live torpedo, taking care to leave the nerves of as great a length as possible. In cutting with the scissars the branches across which these nerves pass, before entering the organ, we may obtain a length of about two or three centimetres (about an inch). When the organ is thus prepared, I place it on varnished taffeta. I then tie one of these nerves with a silk thread, and thus lift it, fixing the other end of the thread to some support. When the experiment is thus arranged, I touch the nerve, sustained by the silk thread, with the two poles of the battery, having a distance of about ten to fifteen millimetres between them. At the moment when the circuit was completed, all the prepared frogs, that were placed on the organ, were seen to contract: at the same time, the needle of the galvanometer, which ought to be very delicate, deviates very sensibly. This deviation, although much weaker than that produced by the living torpedo, indicates, however, the ordinary current from the back to the belly of the torpedo. All these phenomena cease, although the circuit remains complete. As soon as contact is broken, the same phenomena are seen to be repeated, which had been obtained when the current commenced passing. Whether the current be directed from the brain toward the organ, or from the organ toward the brain, the discharge is always excited at the beginning and the end of the current. According as the vitality of the nerve is weakened, the phenomena change: the electric current only excites the discharge when it commences, if it be directed from the brain to the

Digitized by Google

organ; whilst it produces this phenomenon when it ceases, if it be directed from the organ to the brain. These laws are evidently the same as those of the action of the electric current on the motor nerves.

The manner of operating, which we have carefully explained, is safe from all error; and certainly, it cannot be supposed that the contractions of the frogs, and the deviation of the galvanometer, is due to a portion of the current of the battery, diffused, we know not how, through the organ. When this experiment is made, it will be observed, that if, instead of touching the nerve of the organ, the organ itself is touched, the phenomena fail: it is needless to say that this would not happen if it were touched with the poles very near the frogs. I may further add, that the phenomena disappear after a certain time.

By operating with the electric current on the nerves of the organ of a live torpedo, or of one recently killed, we succeed in exciting the discharge in the different parts of this organ. In general, this discharge is confined to the portion of the organ in which is spread, with its ramifications, the nerve excited by the current. By irritating the different nerves of the organ by any stimulating body, the same result is obtained. In order to observe it more easily, it is only requisite to wipe the surface of the organ, in order to limit the region of the discharge.

When the passage of the current is prolonged in the nerves of the organ of a live torpedo, or of one recently killed, it is very manifest that the electric current is considerably weakened, or entirely destroyed. If contact is then broken, and the current is made to pass over the same nerve, and in a direction contrary to that of the current before employed, the discharge is still obtained; and when this second current has ceased to act, by reversing it again, the nerve is found to have recovered the excitability that it had lost. It is needless to say that the discharge thus obtained, sometimes takes place when the circuit is closed, sometimes when it is opened; according as the current is directed from the brain toward the organ, or from the organ toward the brain. Here, again, are phenomena, common to the electric discharge and muscular contraction: these phenomena evidently correspond with the voltaic alternatives.

I have tried, on several live torpedos, the interrupted or the continued passage of a very strong electric current: for which purpose, I placed the torpedo on a large plate of platinum, and I applied a similar plate to his back; after this, I connected the two plates with the poles of a battery, of from sixty

Digitized by Google

to eighty pairs. Sometimes I kept the circuit closed for some minutes; sometimes I interrupted it, to renew it the next moment. In some experiments, I employed the current by directing it — now from the back to the lower part of the belly, and then from the belly to the back. The torpedo, subjected to the continued passage of the electric current, is either paralysed in its electric functions, or loses them for ever by dying. In the former case, after having left it some time in water, discharges may again be obtained, by pressing it between the hands. The torpedo, irritated by the interrupted passage of the electric current, gives a certain number of very strong discharges, and then dies. These phenomena are very similar to those obtained when the electric current is employed to excite muscular contraction.

If one of the organs of a living torpedo is quickly separated from it, and the ramifying ends of one of the nerves is irritated in any way, the electric discharge is obtained. But, according as the vitality weakens, points of these nerves, nearer to the extremities, must be irritated, in order to obtain the discharge; in fact, when they are no longer obtained by cutting the nerves which go out of the organ, they are still obtained, by introducing the scissars into different parts of the organ itself. In a similar manner, the excitability of the motor nerves retires towards their extremities, as vitality decreases.

I introduced into the stomach of a living torpedo several drops of an aqueous solution of the extract of *nux vomica*, slightly acidulated with hydrochloric acid. Some minutes afterwards, the torpedo remaining all the time out of the water, he is seen to give the discharge spontaneously; and the discharge takes place at the least contact with his body. But cutting the spinal marrow of a torpedo, thus under narcotic influence, the contact with his body below the point cut is no longer followed by the discharge; hence the discharge is evidently produced by a movement, reflected through the intervention of the spinal marrow. The celebrated labours of Hall, Flourens, and Muller, have proved that similar phenomena of muscular contraction, are not produced on frogs under the influence of a narcotic.

Very strong discharges are obtained by touching the electric lobe of a living torpedo with a rather concentrated alcaline solution. M. de Humboldt has proved the same thing with respect to muscular contraction.

The facts that we have related prove completely that the electric discharge of the torpedo, and muscular contraction are phenomena, subject to the same laws. Hence it follows that the nerves of the electric organs are as distinct from the

Digitized by Google

other nerves as the nerves of the senses, and the anterior and posterior roots of the spinal marrow. It always happens that the excitation of a nerve produces the phenomenon which belongs to the organ in which, with its ramifications, it is diffused.

I have tried some new experiments, in order to discover the direction of the electric current in the interior of the organ of the torpedo at the moment of the discharge. For this purpose I cut the organ in parallel layers of different thicknesses, taking care all the time to keep the layers separated from each other by the aid of little hooks attached to a silk thread. By touching the surfaces of these layers with the plates of the galvanometer, I have always observed, as in all my preceding labours, that the internal surface,—that one nearer to the back is positive; and that the other, the nearer to the belly, is negative. In some cases, when these layers were extremely thin, the signs of the electric current failed; which especially happened when the nervous trunk belonging to the layer tested had been cut.

I have also tried, by introducing steel needles in different directions and in different parts of the organ, whether these needles would be magnetized during the discharge. I have never obtained any magnetization in the needles thus placed. This result proves nothing else, except that the discharge of the torpedo cannot be compared to that of the Leyden jar. In fact, if the latter kind of discharge is passed through a quantity of water, in which steel needles are sustained in different directions, these needles are found more or less magnetized. Moreover, by renouncing all analogies between the organ of the torpedo and all the sources of electricity with which we are acquainted, we may believe that the discharge of this organ does not traverse its interior, unless this organ has been cut. A rather curious result, at which I have lately arrived, is that of the discharge, obtained from very small pieces of the organ. The experiment was made in the following manner:—I cut the electric organ of a living torpedo, and very quickly detach one of the prisms of this organ with the scissars; I then place on this prism the nerve of the galvanoscopic frog. By wounding this prism in any way, I see the frog contract. Sometimes I have succeeded in this with very small portions of a prism. From this it is manifest, that in each prism, and even in each of its elementary parts, there exists the organization necessary to produce the discharge: each of its elementary parts can give it whenever the little nervous filaments, which enter there, are excited. It is natural to admit, that the total discharge of the torpedo

Digitized by Google

is only the sum of all the elementary discharges, given by all the elementary organs of the different prisms, at the same time; but the more I advance in the study of the electrical phenomena of the torpedo, the more I feel the difficulty of connecting the origin of its functions, with that of the other electric sources.

Lately, while studying the structure of the organ of the torpedo, with my colleague M. Savi, and comparing it with that of the organ of the gymnotus, I have marked the existence of a very important relation between the structure of the organs of these two fishes, and one of the characteristics of their electric discharge. If the organ of a torpedo is cut normally, the columns are seen separated by aponeurotic septa, fixed, at one part, on the dorsal skin; at the other, on the ventral skin. We know that, during the discharge, these two extremities of each column have, the one positive electricity, the other negative. In a gymnotus, cut equally all along its body from head to tail, the same columns are seen in its electric organ as are seen in the organ of the torpedo; but in the gymnotus these columns being placed parallel to the length of the animal, have their extremities at the head and at the tail. The recent observations of Faraday have proved that, in the gymnotus, the two contrary electric states are at the head and at the tail. The extremities of the columns of each of these organs represent the two poles of their electric apparatus.—[T.]

ORIGINAL COMMUNICATIONS.

XII. *On the Earth, as a Conductor and Permanent Generator of Voltaic Electricity.* By Mr. Alexander Bain.

We lose not a moment in availing ourselves of a communication we have just received from Mr. Bain, relative to various experiments, in which he has employed the moisture contained in the earth as an exciting liquid to heterogeneous metals. As some of the facts are new, and not such as theory would have indicated; and, as they promise to be of practical avail, in more ways than one, our present notice cannot but be acceptable to our readers. In this notice, we should not omit to record some preliminary experiments, which involve

Digitized by Google

matter of practical interest; as, for instance, when two wires unprotected and placed side by side in the water, and across the Serpentine in Hyde Park, conveyed the current from a six-celled battery on one side the river, to an electro-magnet on the other side, enough of the current reached the magnet to enable it to sustain its own weight; the greater portion, however, passed from wire to wire through the water; and of this, a greater part passed between any given points of the wire nearer to the battery, than between points more remote. But, when contact was broken on the *battery side* of the river, a remnant of power still existed in the electro-magnet, for as much as ten minutes beyond the cessation of the battery action; although, when contact was broken on the *magnet side* of the river, there was no remnant of power. The cause of this remnant of power does not seem to have been determined: it is doubtless due to a current excited between the two wires themselves, which, from the mere circumstance of having conveyed a current, independently of other extraneous causes, become physically different, so far as electro-motive power is concerned. On using a less powerful battery, less in proportion of the whole amount of the current was lost by dissipation through the water. Other experiments were made, in which the water, and afterwards the moist earth, formed part of the circuit, and wire the remainder; when it was found that when sufficient moisture is present, the earth is a good conductor of voltaic electricity generated in the usual ways.

These experiments were the stepping-stone to the employment of the moisture of the earth itself, for the exciting liquid to the respective elements of a voltaic pair: for Mr. Bain inferred, that if a positive metal were attached to one end of a conducting wire, and a negative metal to the other, and the two metals were then placed in water or buried in the moist earth, while the connecting wire was properly insulated, a current might be generated. This idea was tested in the grounds of Mr. Finlaison, at Epping Forest. Twelve inches surface of one metal was placed in a pond, and connected by an insulated wire with twelve inches of another metal, placed in a moat 150 yards distant; by which means a current of considerable energy was obtained, that deflected a galvanometer in the circuit: the connecting wire, in this case, was laid along a gravel walk. Experiments of this character were now made on a larger scale, at the Serpentine river. A large surface of copper was placed within Kensington Gardens, at the one end of the river; and within Hyde Park, at the other end, was placed a similar surface of zinc; the metals were

Digitized by Google

connected by a wire, in the circuit of which was a galvanometer; and a current of considerable intensity was found to be passing. This experiment was varied by placing the metals on opposite sides of the river, and allowing the connecting wire to hang in the water; when a considerable loss of power occurred.

Having established these points, Mr. Bain next buried a surface of zinc in the moist earth of Hyde Park; and, at rather more than a mile distant, he buried a surface of copper: the metals were connected by a wire suspended on the railings. When the buried metals were small, the current was feeble; but when a larger surface was used, he not only obtained the usual electro-magnetic effects in an enhanced degree, but also succeeded in the performance of electrotype operations, as, in the course of a few minutes, he coated a half-crown with copper. Subsequent experiments have shown him, that if metals are thus buried, and connecting wires are employed, electrotype depositions may be effected, and electro-magnetic apparatus worked, for a great length of time. He states that the power is more than doubled, if each original mass of metal is greatly subdivided, and the portions placed (so to speak) without the radius of their reciprocal actions, and then, by means of wires, grouped into one mass; and he recommends this plan when considerable power is required. He also states that the increase of power obtained by considerably reducing the mile of distance, which intervened between the metals just mentioned, was very small. He anticipates, from the simplicity and economy of the arrangements now described, that electricity from this source may become much used in the arts; and mentions a battery of this kind, under very disadvantageous circumstances, as having acted for six months with unvaried power. The facts here deduced may help to explain the anomalies presenting themselves in the relative intensities of electrolytic action in capacious, as compared with confined cells; and it would seem that, in these great natural reservoirs, whose capacity is without limit, the inductive lines of action have full liberty to expand and elicit a sum of power, which would have been lost, perhaps, in a limited vessel.

We have only space to say that we have received a drawing of Mr. Bain's telegraph, wherein is given the plan he adopts for availing himself of this source of electricity as the electromotive power. He places the zinc in the earth, and in connection with the telegraph at one station; and the copper in like manner, in connection with the telegraph, at another station. We may return to this on another occasion.—[Ed.

Digitized by Google

XIII. Letter from J. P. Gassiot, Esq., F.R.S., &c., to the Editor, containing "*A Description of an Instrument constructed for the Purpose of Measuring the Resistance of Wires interposed in the Circuit, and the Electro-Magnetic Power of different Batteries.*"

(*To the Editor of the Electrical Magazine.*)

My dear Sir,—The accompanying drawings, with a few words of description, will explain to your readers the structure of an instrument which has been made under my directions, and whose action is to register by a dial-plate the number of times contact is broken under the varied circumstances of different electro-motors and modified resistances to which it can be subjected. The base of the instrument is a wooden stand, seven inches in diameter; two short brass columns support the dial and its attendant wheels and pinions, as seen in the drawing. The dial possesses three indices, one pointing out the units, another the tens, and the third the hundreds. Two taller columns sustain the wheel visible at the back in Fig. 1, and constitute parts of the connecting series, which will be better understood by reference to Fig. 2: *a*, a binding screw to connect with one end of the battery: *A*, a brass column, in metallic connection with *a*; *b*, a disc, partly metal, partly ivory, by which the circuit is alternately completed and cut off, the metal portion being in metallic connexion with *A*; *c*, a binding screw holding a spring, which presses on the edge of the disc *b*; *C*, a brass column

Fig. 1.

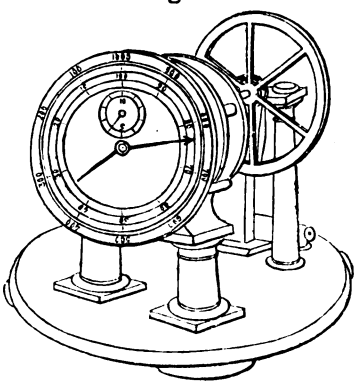
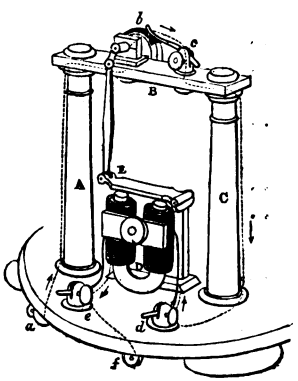


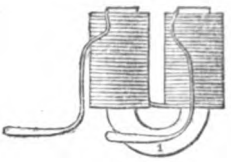
Fig. 2.



Digitized by Google

in metallic connexion with the binding screw *c*; *d*, another binding screw, connected with the base of the column *C*, and containing one end of the wire of the electro-magnet *D*; *e*, a binding screw, containing the other end of the wire, and in metallic connexion with *f*, which forms connexion with the other end of the battery. *E*, the soft iron keeper of the electro-magnet having a hinge at one end, and raising or depressing the perpendicular beam at the other. This beam, by means of a crank, communicates motion to the large wheel, the number of the revolutions of which, being equivalent to the alternations of attraction and cessation, are registered on the dial. The eye may trace the circuit more readily by following the dotted lines, which commence at *a*, and terminate at *f*.

Fig. 3.



The electro magnets, of one of which, Fig. 3, is a sketch, are five in number; their construction is as follows:—

No. 1 magnet, wound with a continuous coil of 16 ft. 2 in. No. 20 copper wire.

2	,,	,,	3 strands each	5	,,	,,	,,
3	,,	,,	continuous coil	4	10	,,	,,
4	,,	,,	,,	16	2	,,	,,
5	,,	,,	,,	3		14	,,

No. 4 magnet made of iron wire. No. 1, 2, 3 and 5, of soft iron from the same bar, each magnet about one inch long.

In illustration of the action of the instrument the following experiments may be taken.

Experiments with No. 1 Magnet—Smee's Battery.

1 cell .. no action
2 ,, .. 550—With a resistance of 15 feet No. 20 copper wire, 195 revolutions per minute.
3 ,, .. 800 530 ,,

With No. 2 Magnet.

2 ,, .. 310 }
3 ,, .. 630 } 15 feet, as above, no action.

No. 1 Magnet—Grove's Battery.

1 ,, .. 920—15 feet wire, 520
2 ,, — ,, 1120

From the preceding experiments, it would appear that it required two cells of Smee's arrangement to obtain 550 revo-

Digitized by Google

lutions per minute; and three cells, 800. While, with one cell of Grove's, 920 revolutions were obtained. That, if 15 feet of No. 20 copper wire were introduced in the circuit, the action of Smee's two cells was reduced from 550 to 195; and three cells, from 800 to 530; and the same resistance introduced in the circuit of one of Grove's, the action was reduced from 920 to 520.

I am, my dear sir, yours very truly, J. P. GASSIOT.

Clapham Common, June 20th, 1843.

SCIENTIFIC MEETINGS.

THE ROYAL INSTITUTION OF GREAT BRITAIN.

Jan. 20th.—The Friday evening meetings of 1843 were opened by Mr. Faraday, who delivered a lecture "On Induction." The ultimate object of the lecture of this evening was to convey some familiar ideas of the probable structure of thunder-clouds, and of the inductive phenomena which precede the disruptive discharge, familiar to all as the lightning-flash; and although the progress toward this end would require the introduction of many familiar, and in the opinion of some, perhaps, common-place *facts*, these were to the philosopher the representatives of any thing but common-place *ideas*. The ordinary effects of induction, as distinct from, and antecedent to the actual passage of electricity, were shown by means of the action of excited glass, or the gold-leaf electroscope, and on Coulomb's electrometer; and the power of inductive action, in arranging electric charges on the surface of conducting bodies, was demonstrated, by charging a conducting globe by means of a carrier-ball, and then encasing the globe in metal hemispheres, sustained on insulating handles; by which means the entire charge was abstracted from the globe and diffused over the surface of the hemispheres, which, under such circumstances, were the true external surface. Similar effects were then illustrated by conveying a charge to an insulated ice-pail; for, however the charge was *given*, it was impossible to abstract any portion, except from the *outside*. This was more decidedly shown by means of a coronal of metal rods, arranged somewhat like those on an earl's coronet, with the addition of others within the circumference. Regarding the whole as a mass, after it had been insulated and charged, no electricity could be abstracted by a carrier, except from some outer part. The same effects were obtained by use of a cylinder of metal gauze; for in this case, although the whole was a conducting mass, and the interstices opened to the eye a ready

Digitized by Google

passage for the charge; and although electricity passes, so that such an interval would require as nothing of time, yet not the least trace could be drawn off by a carrier, except from some outer part of the surface. Mr. Faraday then showed that the interposition of various media does not insulate from the effects of induction. An electroscope was placed in a glass jar, which was covered in succession by glass, sulphur, shell-lac, and metal; the approximation of an excited rod above the several covers produced alike the divergence of the gold leaves. Having alluded to air as the medium of induction between the earth and the clouds, he insulated a twelve-inch ball to show the character of the action of clouds on the earth, and stated that this ball, when charged, would produce a certain electric action on all matter about it, by means of a certain polarity, into which the intervening particles of air would be thrown. On a part of the wall of the lecture-room a handkerchief was stretched, and so arranged that it could be reefed and removed by means of silk threads. The ball, which was many feet distant, was charged; and the handkerchief, on being quickly and carefully removed, communicated to the electroscope very distinct evidence of its electrical condition. Its electrical character was the *reverse* to that of the ball, and this is the case between the earth and clouds. An ice-pail was again placed on the table, and within it was laid a disc of shell-lac; on this disc was placed a smaller vessel, within which was another disc; and on this a third vessel: thus were there three cylinders, *not* in metallic connexion: the external vessel was connected with an electroscope. When a charged carrier-ball was suspended within, the electroscope was affected; when the ball touched the inner cylinder, the effect was as before; when the inner cylinder was drawn out by silk threads, the effect ceased: also, the effect was exactly the same in amount whether the ball was held in the centre or near either side. After these instructive experiments, Mr. Faraday alluded to the electricity of the atmosphere as being required and generated more for the purpose of carrying on the processes of vegetation, than for producing the terrific phenomena of thunder-storms; which latter are to be regarded rather as an exception to the wise designs of nature, than as a rule. A difference of opinion has long prevailed among philosophers respecting the electric condition of the atmosphere: M. Peltier conceives our globe to be electro-negative, and space itself positive: Mr. Faraday thinks it possible that the sun, planets, &c., may be in one state, and the earth in the opposite; but, at present, these are all matters of surmise. That we may be on an electrized plane, and, so far as our senses are concerned, not conscious of our condition, was shown by connecting a large metal disc with the prime conductor, and placing on it a living mouse: the disc was highly electrized by the rotation of the machine, and sparks were drawn from it, but the little animal gave no evidence of inconvenience, unless alarm when sparks were taken somewhat too near him. After alluding to certain mysterious changes,

Digitized by Google

that are not as yet well understood, by which invisible aqueous vapour is converted into visible cloud, Mr. Faraday defined a cloud as an aggregation of watery vesicles, and referred to his previous experiments in proof that the electric charge is virtually accumulated on the surface of such cloud: he confessed there was a difficulty in comprehending the cause of the *unity* of a cloud, when the effect of similarly electrized bodies is to repel each other. This effect he illustrated by means of a tall insulated rod, sustaining a light tassel of tissue-paper: when the machine was turned, the respective shreds of paper elevated themselves into a lively model of the palm tree; and gave a most satisfactory demonstration of the mutual repulsion of such particles. The aggregation of the cloud might, however, be due to the inductive action of the earth; for the ribbons of paper, which stood on end and apart from each other during their electrized condition, would conglomerate if a metal ball, which not inaptly might represent the earth, was brought near any fasciculus of them. By these leading experiments was induction, the corner-stone of electricity, illustrated.

February 10th.—Mr. Grove delivered a lecture on his "Gaseous Voltaic Pile." He opened the lecture by introducing the reasons which have led him to reject the theory that would trace the origin of voltaic electricity to the contact of dissimilar bodies; and he gave experimental proof that Volta's experiment, of obtaining electricity by the mere *contact* of discs of copper and zinc, is equally successful, if the contact is *prevented* by the interposition of a circle of card. He then alluded to the curious fact, which has of late caused so much interest in the scientific world, that a coin, allowed to remain any time on a polished metal plate, will leave behind it a faint picture delineated on the metal: he believes that this may be due to a radiation between the two metals, on account of the essential difference in their temperature; and conceives that a somewhat similar action may take place between Volta's discs, and produce a chemical disturbance. Be this as it may, some facts are well established, in reference to chemical action:—1st, without it there is no voltaic action: 2nd, as the one increases, so does the other; 3rd, as the one ceases, so does the other; 4th, *many*, perhaps *all*, chemical actions may, by proper arrangement, be converted into voltaic. Having first generated hydrogen gas, from zinc and acid water, to illustrate the nature of chemical action, he immersed a pair of zinc and copper in water, and showed that, till the circuit was completed, and chemical action commenced, there was no voltaic; he then immersed a pair, both copper, in dissimilar liquids, separated by a diaphragm, and showed the same. When chemical action was increased, by using a Grove's battery, of platinum and zinc, the one excited by strong nitric, the other by sulphuric acid, the electric effects were of a most exalted character. An acid and an alkali were now mixed, to show chemical action; and this was converted into voltaic, by placing similar liquids in the respective sides of a

Digitized by Google

vessel, divided by a porous diaphragm of animal membrane or clay, and immersing in each a slip of platinum; when the circuit was completed, chemical action commenced, and with it voltaic. Still more, when gold with nitric acid was placed in one glass, and gold with muriatic acid in another, the gold remained intact; but when the liquids were mixed, it was dissolved. This, too, was converted into the voltaic action, by placing the acids in a diaphragm apparatus, and immersing in each a slip of gold gummed on glass; when the current was allowed to pass, the gold in the muriatic acid disappeared. Heretofore Mr. Grove had been treating on the relative actions of solids and liquids, in illustration of the action of the voltaic combinations, with which we are most familiar; he had now to speak of gases. In reference to their non-conductibility, he stated that there is no *absolutism* in nature: all is relative; as, for instance, very thick glass is opaque, and very thin gold transparent; and so, very minute quantities of gaseous matter will operate as conductors. He now generated hydrogen gas, and, as it escaped from an orifice, allowed it to play upon clean platinum: the latter speedily attained a red heat, and, when its temperature increased, it ignited the gas. He admires this as a most beautiful experiment, and considers that it is really and truly a voltaic effect; that the presence of the platinum effects the combination of the hydrogen with the oxygen of the atmosphere, and that, in the process of such combination, heat is generated. This action was still further illustrated by inserting platinum into a mixture of the two gases, and thus producing an instantaneous combination, with its attendant detonation. It now remained to follow out the analogy between these and the earlier experiments, by converting the chemical into voltaic actions, and these led to the construction of the gaseous voltaic pile. Now, in former instances, the electrolytes, or liquids susceptible of chemical decomposition, were kept separate by diaphragms, and a similar provision is manifestly needed in the present case; and, as solid diaphragms were best fitted to the one arrangement, so are liquid to the other. The pile is, therefore, thus arranged:—a vessel is filled with acid water; in it are inserted two glass tubes, the one containing oxygen, the other hydrogen; in each is a slip of platinized platinum, that is, platinum on which particles of platinum have previously been thrown down in fine powder, by voltaic action,—this process being adopted in order that the whole surface of the platinum may be wet. A collection of such cells is arranged in series as in the ordinary piles. When the circuit is completed, the oxygen in the one tube combines with the hydrogen of the particle of water next contiguous to it; and the hydrogen in the other tube combines with the oxygen of the particle of water next contiguous to it; and, in process of time, the gases, in their just equivalents, disappear from both tubes. This pile produces all the effects of voltaic electricity; but they are, contrary to what is the case with the nitric acid battery, each on a small scale. In a theoretical view this arrangement is most valua-

Digitized by Google

ble; and it is very interesting to observe, that while the production of water by the union of the gases is the cause of the voltaic action, the decomposition, or conversion of water into the self-same gases, is the effect of such action; and that exactly the same quantities of gases are generated in the Voltameter as are consumed in each cell of the pile itself. Moreover, if the respective tubes in the pile were charged with gases that do not combine chemically, there would be no voltaic action. Mr. Grove did not care to answer the common-place question, *Cui bono?* He knew this discovery was only the inception of a new idea, and would not attempt to divine to what extent fact would follow fact in one continued train, to reveal more and more of that truth after which we so anxiously seek.

March 10.—Mr. Smee lectured "On Electro-Metallurgy."—Mr. Smee introduced the subject, by referring to old experiments which long ago familiarised us with the decomposition of metallic solutions, and the release of the metal at a given spot; and he then stated that the power of so arranging the apparatus as to produce a *reguline* deposit is one of more recent date. He described the power of a voltaic pile as due to the chemical affinity between one of the metals (whether zinc, iron, tin, copper, &c.) and one element of a binary compound; as in the case of zinc and the oxygen of water; and he went on to state that the greater the affinity, the greater is the amount of electrical power generated by such action. He described four resistances, which are opposed to the power thus generated. 1st. The distance between the two metals, being the number of liquid particles interposed. This was illustrated by passing the current along an electrolyte, contained in a series of bent tubes, by which means a great resistance was offered to its passage; and hence a great reduction in its effects ensued: this arrangement was contrived by Mr. Gassiot. 2nd. The tendency of the liberated hydrogen to adhere to the negative plate, was described as another interfering cause; this is obviated in a great degree by the platinized platinum battery, now well known as Smee's arrangement; but, independently of other advantages, Mr. Grove's nitric-acid battery is very effectual in producing this ready liberation of the element eliminated on the platinum. 3rd. The connecting arrangements are another source of resistance; but these, so far as the *metallic* portion is concerned, need not be regarded in electrotype experiments. 4th. The presence of the compound, produced by the affinity to which the power is due; as, for instance, the production of oxide of zinc in the common arrangements, is a last obstruction. This compound is removed by the presence of water and other agents (as sulphuric acid, for example), in which it is soluble. The perfection of electro-metallurgy consists in a knowledge of the laws, by which these several elements of voltaic action are to be adjusted to the work in hand. Mr. Smee then went on to trace the reduction of metals from their solutions, not to any attraction, as was once imagined, developed

Digitized by Google

by the respective poles, nor yet to any *direct* electrolytic action, but solely, as he believes, to the presence of *nascent hydrogen*,—hydrogen (as he explained) *closely attached to the negative plate.* He illustrated this by forming a pair with amalgamated zinc and coke, and placing them, for some little time, in acid water: the hydrogen was not, at the commencement of the experiment, visible to the eye; because it closely adheres (as Mr. Smee explained) in the interstices of the coke. The coke was then removed from the zinc, and immersed in a solution of sulphate of copper, when a deposition of that metal occurred on its surface, which, according to Mr. Smee's views, is due to the sole action of the hydrogen. He carried out this idea by introducing experiments wherein metals were liberated from solutions of chloride of gold, of a per-salt of iron, and of sulphate of copper, by the mere presence of free hydrogen. The hydrogen, in such cases, disappears in proportions, which are the equivalents to the metal reduced; and these portions, uniting with the corresponding equivalents of oxygen, previously in union with the metal, produce *water.* On this account it is that, in electrotype operations, the mould to receive the deposit is better placed *beneath* than *above* the plate supplying the metal; because the water, formed by the combination alluded to, being of less specific gravity than the rest of the solution, will, by such arrangement, rise away from the plate, and not interfere with the regular electrolytic action. The effects of operating on mixed solutions were then explained; and Mr. Smee alluded to the regular order, with which each metal would appear from a mixed solution, and pointed out the practical impossibility of throwing down alloys, as, for instance, as some one had unwisely suggested, coating the light sovereigns with standard gold. He concluded the lecture with a review of the many arts which have arisen from these voltaic powers, as electro-gilding and plating, electro-glyphography, or the art of producing copper blocks which may be placed among the type and printed from as wood blocks; electro-tint, with which we are now well familiar, being the production of plates to be used as ordinary copper plates; the printing of playing-cards by M. de la Rue; calico printing; copying busts and statues; protecting chronometer springs; zincing; and even coppering the bottoms of vessels. Models of vessels thus protected were exhibited, and they were certainly very beautifully done; the gentleman who produced them has also coppered, by similar means, a boat fifteen feet long.

June 9th.—Mr. Faraday delivered a lecture "On the Electricity of Steam." He alluded first to certain facts, which the scientific world have long possessed, relative to the production of electricity in particular conditions of the conversion of water into steam; and he spoke of the very important inquiry connected with these facts,—viz., Does the electricity of the atmosphere depend on the evaporation from the earth, or does it not? Does lightning owe its origin to the conversion of water into vapour or not?

Digitized by Google

However interesting these inquiries may be, and however anxious we may feel to solve the important queries, the experiments to be detailed throw no light whatever on the subject. First, in reference to the old experiments, a hot crucible was placed on an insulating stand, connected with an electroscope, and water was poured in: the leaves did not diverge immediately, although very much steam was being given off; but as the crucible became cooler the divergence, which is the well-known indication of the presence of electricity, commenced. Again; a silver vessel was heated over a lamp, and a little hot water was dropped into it; but no electricity occurred until the heat was removed, and the vessel became cooler; for until this time the water was isolated from the metal by a thin layer of steam; in fact, as Mr. Faraday remarked, the electricity is only developed at the moment of transition to a rapid boiling, on the first contact of the water with the metal; and this was the sum of our knowledge of the electricity of steam, until within a very recent period.—An incident, which occurred about two years ago, to a workman in charge of a boiler of a steam engine, has paved the way to the new and interesting series of enquiries, the results of which were the subject of the present lecture. The man in question observed a spark proceed from the boiler to his hand, and not unreasonably was led to infer that more sparks were resident whence that one came; in fact, that the boiler was filled with fire. On communicating his suspicions to Mr. Armstrong, that gentleman and others readily perceived that electricity was the source of this phenomenon; and, in the experiments which were instituted in consequence of this discovery, they found means to arrange apparatus from which sparks, as much as two feet in length, were disengaged.* Mr. Faraday now entered on the description of an arrangement he had prepared, for the purpose of illustrating these phenomena. It consisted of a boiler, with its attached furnace, standing on cakes of shell-lac; and of a steam pipe, proceeding horizontally from the boiler, and sustained on insulating supports; the steam pipe was interrupted, between the boiler and the jet, by a metal globe, fitted for containing liquid, so that the steam, in passing out, might blow over the surface of this liquid: the globe possessed means for drawing off its contents, and for replenishing it:—the use of this part of the arrangement will soon be made evident.

Mr. Faraday now showed the test he would use for the presence of electricity. He excited a glass rod, and conveyed a charge thus to the boiler, when the leaves of a connected electroscope immediately diverged. This test being recognized, he proceeded to blow off the steam through the pipe above described; and this caused a similar divergence of the leaves;—while the steam was passing off, he drew a spark from the jet or from the boiler; he also charged a Leyden jar; and, by holding a receiver of gas near

* Vide Proceed. Elec. Soc. p. 527.—Ed.

Digitized by Google

the boiler, the gas was readily inflamed ;—in a similar manner he had succeeded in igniting combustible combinations. The character of the electrized condition of the *boiler* was then shown, by the usual tests, to be *negative*. But the inquiry which then naturally suggested itself was, is the steam itself electrized ? and, if so, what is its character ? An insulated brass conductor, having an electroscope, connected with its further extremity, was placed near the jet ; and the steam was allowed to rush among the interstices of wire-gauze attached to its nearer end :—the leaves diverged as before ; but, on applying the test, it was shown that the electricity of the *steam* is *positive*.

Now came the inquiry into the cause of this development ; and the great question is, Is it due to evaporation ? If so, it would be a ready transition to the explanation of atmospheric electricity and lightning. Although, as the results show, it does not arise from evaporation, and hence affords not the clue to elucidate the mystery, which still hangs around those magnificent natural phenomena,—thus losing one portion of its interest, yet it possesses a peculiar beauty of its own, and one which will well repay the attention bestowed upon it. That it is not due to evaporation,—to the mere transition of water into vapour, was readily shown ; for, on a portion of the steam-pipe being removed, although the steam was blown off with its pristine violence, not a trace of electricity was manifest. This illustrated two points,—viz., that it was neither caused by evaporation, nor by the mere issue of steam. On replacing the rest of the tube, and blowing off the steam, no electricity was obtained, until the globe above named was re-supplied with *water ;* nor then, indeed, did the effects return, until such time as the passing steam had greatly raised the *temperature* of the water. The inference drawn by Mr. Faraday from these facts is, that steam, as such, is only concerned in the production of these phenomena, inasmuch as it is a mechanical means of conveying the particles of water onward, and producing with them a powerful friction against the sides of the tube ;—*to the friction of which particles of water the whole effects are due.*

Another remarkable fact is, that the *rubbing* particles must be of *pure* water. This was readily shown by dropping a few crystals of Glauber's salt into the globe, which at once put an end to the effects. Mr. Faraday mentioned that he had varied this experiment considerably, using the different salts contained in sea-water, and many others. The introduction of any of these substances destroys the effect, by giving conducting power to the water. So long as the globe contains distilled water, there is no need for the boiler to have pure water, because the rubbing particles, whether derived from the condensed steam or from the water in the globe, are themselves pure. These effects suffer modifications according to the pressure of the steam ; the higher it is, the less pure need the water be. That the cessation of effect, when salts were introduced, was in consequence of their giving conducting power to

Digitized by Google

the watery particles, was beautifully illustrated by dropping in a solution of ammonia, which does not render water conducteous; for the effects continued as before;—but the moment sulphuric acid was added, which formed, with the ammonia, a conducting salt, the electric action ceased.

The jets have been furnished with opposing cones of glass, ivory, sulphur, silk, lac, wood, &c., affording surfaces for receiving the friction; the latter is described as the best material: the electricity is also produced by a jet of damp air. Some anomalous effects were exhibited by allowing the steam to play on wire gauze at various distances; and they were shewn to be due to the gauze exciting electricity, when the friction was great, and only collecting it when it was less.

Mr. Faraday here alluded to the conflicting results which had attended the original inquiries in this matter; and proceeded to show how slight a circumstance would alter the character of the phenomena. He screwed a small glass funnel over the jet, having so arranged it, that, by means of a stop-cock, he could open communication with the jet, and introduce extraneous matter. Having seen all things in order, and the electroscope diverging *negative*, while the steam was blowing off, he selected oil of turpentine, and allowed a drop to fall into the jet, immediately the character of the divergence becomes *positive*. By allowing the steam to continue passing out, the leaves gradually assumed a neutral state; and, as the oil was dissipated, they again acquired the negative condition. Fixed oil, resin, &c., have the same effect; and hence there can be little surprise at the anomalous results which puzzled the first inquirers; for the mere transition from a well-cleaned jet to another, having on it traces of oil, would give out the converse effect.

Mr. Faraday expressed the diffidence with which he advanced speculative opinions; but he could not here resist suggesting, that the diametrically opposed results in these cases were due to the oil spreading itself over the entire surface of the aqueous particles, and virtually creating a rubbing surface of oil, instead of one of water. In illustration of this opinion, which must include the fact of an *instantaneous* diffusion of the oil, a balance-pan, resting on the surface of water, was so counterposed that an increase of weight on the one hand, or a diminution of cohesion on the other, would cause it to ascend: a single drop of oil of turpentine was applied on the surface of the water, and simultaneous with the application the scale was liberated.

Having thus led his hearers through the leading features of the electricity of steam, the lecture was concluded; and with it terminated the Friday evening meetings for the present season.

INSTITUTION OF CIVIL ENGINEERS.

May 16th.—A paper by Mr. F. Pellatt was read, descriptive of Mr. Elkington's process of coating metals with pure zinc, as a protection

Digitized by Google

against the weather, &c. The zinc being deposited by electrolytic action, is free from the defects of impurity, which so militate against the successful application of metals coated with merely melted zinc. The cost is said not to exceed that of four coats of oil-paint. We hope to return to this subject soon, and give our readers a more detailed account of the process.

May 30th.—A pair of Prof. Wheatstone's electro-magnetic-signal-telegraphs were exhibited and explained. As in his last telegraphs, so in these, an index advances by the alternate action of an electro-magnet, as contact is made and broken at the other extremity of the line. This telegraph possesses only the limited number of six elementary signals (being all that are needed for the Aix-la-Chapelle inclined plane, where it will be used); of these, five are available, and by their varied combinations give twenty-five signals. Arrangements are made for facilitating the return of the index to the resting-point; also for transmitting permanent signals. The telegraph only requires a single circuit of communication between the stations; whereas Mr. Wheatstone's former arrangements required as many circuits as there were signals. The earth, or an extent of water, will be employed at Aix-la-Chapelle, to complete the circuit, instead of a wire. It was stated that Prof. Steinheil had employed the earth to complete the circuit of the electro-magnetic-telegraph, which he established at Munich, in 1838. In 1842 Mr. Wheatstone employed the same channel at Berlin; and, in the same year, he formed a communication between King's College and the Shot Tower on the opposite side of the Thames, by a wire passing along the parapet of Waterloo-bridge, as one portion of the circuit; and by the breadth of the Thames, as the other, communication being made with the latter by means of plates of zinc plunged into the mud of the river. A magneto-electric machine may be used with this telegraph; and as this source of electricity is always in order, and requires no constant attention, the instruments are at all times ready for action.

SOCIETY OF ARTS.

May 17th.—A paper was read, describing Mr. Cooke's practical electric telegraph, as now used on the Great Western Railway. Instead of the original plan of laying the telegraphic wires in iron tubes, they are now sustained on poles sixteen or eighteen feet high, at a distance of 500 or 600 yards apart. This plan reduces the cost to one-half, gives superior insulation, and offers greater facility of repair. Iron wire (No. 7 or 8) is used; it is tightened between the posts by reels with ratchet-wheels, of which every post has one for each wire. Wooden standards, sixty or seventy yards apart, support the wires. The insulation is effected by the use of earthenware or glass. The earth itself is now employed to complete the circuit, by which means one wire is saved. For two years Mr. Cooke has tried this plan with success on the Blackwall Railway, and lately on the Manchester and Leeds line.

Digitized by Google

REVIEWS AND NOTICES.

The London, Edinburgh, and Dublin Philosophical Magazine. January to June, 1843. RICHARD and JOHN TAYLOR, Red Lion Court, Fleet Street.

A LEADING feature in the compact into which we have entered with our readers, is to keep pace with the progress of electricity, and acquaint them with anything of interest which may transpire during the quarterly interval between our respective days of publication. To this end, our attention is naturally drawn toward the *Philosophical Magazine*, and a first duty with us is to give a condensed notice of the electrical papers that have appeared there. We, in the present instance, take the six numbers of the passing year, from January to June inclusive; and, as they are far from being poor in electricity, we must be very brief in our observations, lest space should fail us.

January Number.—Mr. Armstrong describes the perfection he has attained with his steam electrical apparatus, and gives comparative experiments, which show that his boiler, of 3 ft. 6 in. by 1 ft. 6 in., produces seven times as much electricity as a plate machine three feet in diameter, worked at seventy revolutions per minute. He finds it "much more effectual to collect electricity from the boiler than from the steam-cloud; but in order to obtain the highest effect from the boiler, the electricity of the steam must be carried to the earth by means of proper conductors." The sparks he obtains, even under disadvantageous circumstances, are twelve inches. He says, "I find it essential to a high development of electricity, that the steam should be discharged with a slight intermixture of water." He has found hard wood (such as ebony or partridge wood) the best material for the discharging passage; and he discharges the steam horizontally in diverging jets (for he uses several), and at a pressure of 70 lbs. on the square inch. He adds—"Although it is perfectly clear that the electricity is excited in the discharging passages, where the steam is exposed to violent friction, yet as the mode of ejection, which I have described, is neither characterised by peculiar violence of friction, nor by great extent of rubbing surface acted upon by the steam, I feel great difficulty in accounting for its extraordinary efficacy, upon the supposition that *friction* is the exclusive cause of the excitation."

March Number.—Professor Schœnbein has made a few observations relative to Mr. Grove's gaseous battery, and refers to some investigations of his own, bearing upon the recent researches of our English philosopher. His opinion of the part sustained by oxygen, in the said arrangements, may be thus condensed:—if pure water and an aqueous solution of hydrogen are voltaically connected by platinum, a current passes toward the pure water, though no free

STANFORD LIBRARIES

Digitized by Google

oxygen is present; and the current is not increased by passing air or oxygen into the solution of hydrogen; and hence he infers that the current "cannot be due to the combination of free hydrogen with isolated oxygen;" which inference, he says, "may be drawn from Mr. Grove's arrangement itself; for the oxygen contained in one tube cannot be supposed to combine with the hydrogen enclosed in another tube." True; such a supposition is not tenable; and such is not Mr. Grove's theory of its action (at least, if we can trust our notes of his lecture*): he recognizes the well-established action of contiguous particles in the intervening electrolyte.

Mr. Schœnbein goes on to say that, as pure water voltaically connected with oxygen does not produce a current, oxygen does not immediately contribute to the action of the gaseous battery, unless by exerting a depolarizing action on the platinum in contact with it. He, however, acknowledges that very likely some other electromotive force is called into play in the oxygen tubes. He infers, in conclusion, from experiments he made some time ago, that chlorine, in place of oxygen, enhances the effects. We refer our readers to the report of Mr. Grove's lecture, in which his theory is included.

— This number contains a letter from Prof. Faraday, which is very valuable, inasmuch as it explains the probable structure of thunder-clouds; and in some degree satisfies the mind as to the effect of the aggregation of isolated electrized particles, such as the vesicles of a cloud may be. An ice-pail is insulated and connected with an electroscope: if an electrized carrier-ball is suspended within, the divergence of the gold-leaves is equal in amount, whether it is made to act by induction on the metal of the pail, or to communicate its charge to it; whether it is held concentric or eccentric, near the surface or near the bottom. Again: if several pails be placed one within the other, resting on isolating plates of shell-lac, the action is the same as with one pail; and whether the charge be in the carrier-ball, or be transferred in succession from one to another of the series of pails, the divergence is the same. Nor is any alteration produced by introducing thick vessels of shell-lac or sulphur between the pails. And further; if, in place of one carrier, several be suspended in either of these systems, each acts independently of the other, and the effect of their united forces is obtained; and whatever changes may be made in the distribution of these respective charges, such as discharging one by contact with either pail, still the same ultimate amount of force is displayed. Similar phenomena are produced by suspending excited pieces of lac within the vessels; except, of course, that they cannot be discharged by contact. One important inference is deduced from these and similar experiments:—"there is no state of static electric force, corresponding to the terms of *simulated* or *disguised*

* Vide Elec. Mag., p. 57, 58.

Digitized by Google

or *latent* electricity, away from the ordinary principles of inductive action; nor is there any case where the electricity is *more latent* or *more disguised*, than when it exists upon the charged conductor of an electrical machine, and is ready to give a powerful spark to any body brought near it."

It follows, from the above experiments, that if the space within a large metallic globe were occupied by myriads of charged vesicles or particles, each insulated from its neighbour, the outsides of the globe would be charged by induction with a force equal to the *sum* of all their forces, and would give as long a spark as if the charges themselves were all congregated on the surface of the globe. The link, by which such a globe is connected with a charged cloud, is readily seen; and hence, as Mr. Faraday concludes, "when a charged cloud is over the earth, although its electricity may be diffused over every one of its particles, and no important part of the *inductive* charge be accumulated upon its under surface, yet the induction upon the earth will be as strong as if all that portion of force, which is directed towards the earth, *were* on that surface."

— Mr. Joule has continued his experiments on the electrical origin of chemical heat, on the hypothesis of its arising from resistance to the conduction of electricity between oxygen and the combustibles at the moment of their union. He introduces a table of Dulong's, in which copper, converted into protoxide, is included, this metal not being mentioned in his former paper; and the heat evolved in the electrolysis of an equivalent of copper is given at 9·97°; and this is the measure of the intensity of the electric current passing between the equivalents of the respective elements at the time of their union. He describes "three forces in operation, of which two are against, and one is for, a current engaged in electrolyzing the solution of the sulphate of a metallic oxide. The first two are the affinity of the elements of the oxide, and that of the oxide for sulphuric acid; and the third, which is in a contrary direction to the two others, and generally less than either is the affinity of water for sulphuric acid. He describes the mode in which he eliminates the two latter. He also gives some experiments which seem to indicate that heat is lost when light is evolved; but this loss is so trivial that it needs not be estimated in the experiments on combustion.

April Number.—A short note from Dr. Faraday, on his disinclination to controversial writing, contains his decided impressions in favour of his original view of static induction; and also of the consistency of the chemical theory of voltaic action.

June Number—Mr. Alex. R. Arrott had communicated to the Chemical Society some new cases of voltaic action, and had described a battery without the use of oxidizable metals. The following is the analysis of his communication :—

Digitized by Google

He alludes to the polarization of the electrodes, as being the recognized cause of counter-currents; and to Becquérel's opinion that such currents are due to the combination of acid and alkali at the positive and negative surfaces. He then states that he has observed currents where no such union, nor even the action of liquids on metals takes place; as when solutions of a per- and proto-salt of iron, are electrically connected by platinum, the per-salt becomes deoxidized and the proto-salt oxidated. As it seems that these effects were produced by means of the elements of water, which was decomposed, he thought, substances, having a greater attraction for either of these elements, would increase the effect. He used chlorine with success; "but iodine produced a very feeble effect from its nearly equal tendency to unite with hydrogen and oxygen. The battery alluded to consists of six jars containing porous tubes, with small platinum cylinders to go within the tubes, and larger platinum cylinders to be placed in the jars. The tubes are filled with strong nitric acid, and the jars with a solution of sulphuret of potassium. With such an instrument he obtained $\frac{1}{2}$ cub. in. of the mixed gases per minute. Various other combinations have been found effectual, and with various degrees of effect. One pair, excited with chlorine or nitric acid, and an alkaline sulphuret, will decompose water. In all cases, an oxidating and a deoxidating substance is employed; but where one substance alone is used, as chlorine, an element is evolved, which reduces the effect." The author then states the conclusions he has reached relative to the law of action in the voltaic battery; that action and re-action are equal and opposite; and he illustrates this by electrolyzing contiguous solutions of per- and proto-sulphate of iron, wherein he obtains no metallic deposit, nor liberation of gas, but increases the one salt at the expense of the other; and he then reverses the experiment, by altering the connections. The general law he derives is that, when a current passes through a series of conductors, it induces a state of things, capable of producing a current equal to itself in amount and opposite in direction; the only exception being when two pieces of the same metal communicate by means of one of its salts. He then lays down certain considerations, which lead him to conclude that "voltaic action is nothing more than chemical action taking place in circumstances that enable us to observe many of the phenomena to which it gives rise, and which we have no means of observing in ordinary cases; and that chemical action is the result of the tendency of the molecules to arrange themselves in a state of equilibrium, in the same manner as ordinary mechanical forces."

— Dr. R. Mallet, of Dublin, has adopted the electrotype process for depositing copper as a coating to the glass tubes, which, in organic analysis, are subjected to intense heat, conjoined with the elastic pressure of the contained gas. He first charges the tube with the subject of analysis; and, having drawn it out, seals the

Digitized by Google

necks; he now brushes on a thin layer of Canada balsam and turpentine, and coats it with plumbago; after which he applies the usual process for depositing copper; and obtains a tube, so completely air-tight, that should the glass crack, during the combustion, it is of little importance. He recommends the application of this process to many other chemical arrangements.

— The present number contains some observations by Dr. Hare, on the electrolysis of salts, together with a reply thereto by Prof. Daniell. We have not space to take our readers through the observations, but can give their general character, and the state of the question between these two philosophers, by extracting a portion of Mr. Daniell's reply: —

"It appears, then, to Dr. Hare, that in the electrolysis of saline solutions, the simultaneous appearance of the elements of water, and of acid and alkali, at the electrodes, may be accounted for simply by the electrolyzation of the soda (taking sulphate of soda as an illustration) which must be the *natural consequence* of the exposure of the sulphate of that base in the circuit. I presume that by the term, *natural consequence*, is meant that such a result might have been, *à priori*, expected; but there is nothing, I think, that I should have anticipated less than that a solution of sulphate of soda would be affected by the voltaic current, precisely in the same way as a solution of caustic soda, or that the powerful affinities of the acid and the base should have no influence upon the result.

"The whole of Dr. Hare's argument is founded upon the supposition, that both in an aqueous solution of soda, and of sulphate of soda, 'the alkali is the primary object of attack, the decomposition of water being a secondary result.' But he has neglected the important fact, that in neither case is it the sodium and the oxygen, which alone *travel* in the circuit; but in the first case the water, and in the second case the acid accompanies the oxygen to the *anode*."

— This number also contains that portion of Dr. Faraday's researches, which treats on the improbable nature of the assumed contact force. We cannot do less than revive in the minds of our readers the leading ideas of this philosopher on this famous source of divers opinions.

He allows that, in many cases, the opposite electricities are induced by the contact of dissimilar metals; but the contact theory assumes that these particles can discharge their states to each other, and yet remain in the state they were first in, being *in every point* entirely unchanged by what had previously taken place; in fact, that a force, which was able to overcome powerful resistance, can arise out of nothing; that, without any change in the acting matter, or the consumption of any generating force, a current can be produced, which shall go on for ever against a constant resistance, or only be stopped, as in a voltaic trough, by the ruin

Digitized by Google

which its exertion has heaped up in its own course, which would be a *creation of power*, and unlike any other force in nature. Whereas the chemical theory, on the other hand, sets out with a power, the existence of which is pre-proved; rarely assuming anything unsupported by a simple chemical fact.

The American Journal of Science and Arts. By Prof. SILLIMAN and B. SILLIMAN, Jun. Nos. 1 and 2, 1843. Wiley and Putnam.

OUR only concern, in the contents of periodicals which may pass under our view, is in respect to any thing on Electricity. The January number of Silliman's Journal contains, a "description of a carbon voltaic battery," by B. Silliman, jun., of which we must take a brief review, in connection with the other communications on the same subject contained in our present number. The form of the arrangement adopted by Mr. Silliman is circular; the zinc is the exterior metal, excited with acidulated water: the plumbago is a solid cylinder, and immersed in nitric acid: some mechanical adjustments are introduced for facilitating the removal of the elements from the solutions. But one very important feature is deficient in this description, namely, the mode of preparing the plumbago. All we have on this point is contained in the following words:—"The plumbago here employed is the artificial mixture made at the crucible works, and crowded into moulds of the proper shape, and baked:" and the name of the manufacturers is given. Mr. Silliman says, that the difficulty in procuring cylinders of native plumbago arises not so much from want of material, as from the occurrence in it of numerous natural joints, which cause it to fall to pieces under the saw; but that the native is superior to the artificial. He has not had the opportunity of comparing the carbon with the platinum battery; but considers it nearly equal. He has employed one for eight hours with constant effects. Like M. Bunsen, he speaks of the carbon obtained in gas retorts; but the difficulty of working it renders it of little avail: he has tried anthracite and bituminous coal, but not with success. In a postscript to this description Mr. Silliman mentions, that since writing the article in hand he had seen, in the "Phil. Mag." for January, 1840, Mr. Cooper's notice of having employed plumbago and other forms of carbon in voltaic arrangements, to whom he yields the title of priority. He also speaks of a carbon battery having been employed in Germany for more than a year previous, which may, doubtless, be M. Bunsen's. Mr. Silliman, in conclusion, speaks of a battery contrived by Prof. Morse, which he says surpasses in constancy any heretofore made, which remains in good working condition without interruption for seven or eight days. "Its peculiarity is in interposing between the zinc and platinum of Mr. Grove's arrangement

Digitized by Google

a second porous cell, containing strong sulphuric acid, which interrupts the mixing of the nitric with the dilute sulphuric acid, or *vice versâ*. Perhaps we shall be deficient in this notice should we omit recording the power of the battery described. Six cells, with plumbago an inch in diameter, and two inches high, opposed by amalgamated zinc coil, $2\frac{1}{4}$ inches in diameter, and of the same height, gave four cubic inches of mixed gases in less than 50″. This communication is dated Dec. 14, 1842.

No. 2 contains a table of the variation of the magnetic-needle at Providence, R. I., from 1817 to 1843, drawn out by Mr. Lockwood. It appears from this table, that in 1817 the variation was 9° 36′ W., which decreased until 1790, when it was 6° 10′: since that period it has increased, and now, 1843, is 8° 46′.

Annales de Chimie et de Physique. Fontin, Masson and Co., Paris. January to April.

These numbers contain some electrical papers, which are already in our pages from another source; and also a translation of Poggendorff's "Method of determining numerically the electro-motive force of a Constant Battery." This is in the January number, and we allude to it now, that our mathematical readers may know that such a paper has appeared. Should circumstances permit, we may be induced on some future day to give an abstract of it. The April number contains a paper by M. Abria, "On the laws of the induction of currents by currents;" and a memoir by M. Matteucci, "On the existence of the muscular electric current in living or recently killed animals." We have not space at present to make any remarks on either of these papers.

NOTICES OF EXPERIMENTS, &c.

The following interesting illustrations of the action of ordinary electricity were introduced in a course of lectures lately delivered by Professor Faraday, at the Royal Institution:—

A cylinder of wire gauze was placed on an insulating stand; a small charge of electricity was communicated to its inner surface, by means of a carrier-ball: a Coulomb's proof plane was now applied to abstract a portion of the charge for testing;—the beauty of the experiment consists in this, that no charge can be taken from the inside,—that, although there is free and open access between the respective sides, and although the rate at which electricity moves is such as almost to annihilate distances, yet the

Digitized by Google

power of induction is such that it more than counterbalances every other tendency and retains the charge on the outer surface of the body.

— This permanent residence of a charge on the external surface, without regard to the individual elements of which this surface is made up, was happily illustrated by the following means:—An insulating staff sustained a conical muslin bag, which was stiff enough to preserve its form; the cone was in a horizontal position: when a charge was conveyed to the bag, by means of a carrier-ball, the electricity arranged itself on the outer surface of the cone; the cone was now drawn inside out by means of a silk thread, so that the surface of muslin, which then formed the inner, now formed the outer superficies. The immediate passage of the charge from the one surface of the muslin to the other, in order still to be on the outer surface, was the necessary consequence.

— Again—an ice-pail, standing on an insulated metal stand, was charged; and the electricity was immediately arranged on its outer surface: a series of brass columns, taller than the ice-pail, were placed around it on the metal plane: under these circumstances no electricity could be gathered by the carrier, except from some outer surface of one of these columns; but, when the pail was raised, by means of a silk thread (a chain still retaining it in metallic connection), and its upper edge brought above the height of the columns, this edge immediately contained a portion of the charge, but lost it again, on being depressed below the height of the apex of the columns.

— A still more general illustration of this result of induction was shown by means of a Leyden arrangement, consisting of two cylinders of metal gauze for the coatings, and an intervening dielectric of air: the inner cylinder rested on a disc of shell-lac. The proposition, illustrated by this apparatus, was that the charge of the one electricity arranged itself about the outer coating of the inner cylinder, while that of the other was arranged about the inner coating of the outer. Coulomb's plane was readily passed between the two in the interval of air, and the charge was tested by the torsion electrometer.

The following phenomena are related by M. de la Rive, as having presented themselves to him during the course of his experiments.

"The first of these phenomena is the formation of a certain black pulverulent substance, which constantly appears when a strong voltaic current is made to pass, for some time, through sulphuric acid, diluted with from six to ten parts of water, or perhaps more. This powder, which remains a long time suspended in the liquid, finally deposits itself at the bottom of the vessel; it consists of minutely-divided platinum. Here the current is always directed in the same direction; or, at least, each electrode has perhaps served alternately four or five times at most, as the positive

Digitized by Google

or as the negative pole of the battery. Does the disaggregation of the platinum, to which this pulverulent matter is due, arise from an oxidation, which the negative electrode undergoes, by the effect of the oxygen which, escaping in a mass from the positive electrode, is held partly in a state of solution in the liquid,—an oxidation always followed by a reduction made by the hydrogen, which disengages itself from the same negative pole?—

"A second phenomenon, which I intend to notice, is that which is seen when a jet of mercury, about a millimetre (·039 in.) in diameter, is placed in the circuit of a strong current, the jet being under a pressure of two atmospheres, in such a direction that it describes a parabola. It is only the part of the jet, very near the orifice, which can transmit the current,—a phenomenon that agrees with the observation of M. Savart, that 'the liquid vein becomes discontinued at no very great distance from the orifice.' And in this conducting portion, the small part most distant from the aperture is that which becomes heated and incandescent. But, at this state of incandescence, it presents a curious aspect; instead of appearing to have a projecting movement forwards, the thread of mercury seems to be composed, in its portion rendered luminous by the current, of brilliant globules, which turn with great rapidity upon themselves.—

"Finally, another phenomenon that I have had occasion to observe, is a very marked vibratory motion, which accompanies the production of light between two charcoal points, placed each in communication with the poles of a battery. It is not necessary that the battery be very powerful. The two charcoal points are held horizontally, by elastic metallic rods, which permit the extremities to touch, without there being the least pressure one against the other. As soon as the current is established, the light starts between the points, and there is heard, as it were, a very rapid series of little detonations, which, in communicating from the charcoal to the metal, make this latter vibrate so as to produce a sound, and even so that these vibrations may be sensible to the touch. This effect is in nowise due to an alternation of electric attractions and repulsions, which might take place between the two charcoal points placed at the two poles; of this I have fully assured myself. The noise in question has not, moreover, any relation to that which two charcoal points make by being rubbed against each other; besides, it is the same with two points of the softest charcoal (such as charcoal of poplar) as it is with two points of the hardest charcoal (such as that obtained from the retorts in which gas is prepared). It is a sort of regular crackling, which takes place between the molecules of charcoal traversed by the current; a crackling which is followed, as we know, by a transport of the particles of charcoal from the positive pole to the negative. With spongy platinum the same noise is not heard; although, however, the molecules of platinum are seen to be detached from the positive pole, and form, by their re-union as it were, a kind of ramifications

Digitized by Google

which are directed towards the negative pole,—ramifications which the high temperature produced by the current renders incandescent, and consolidates by their fusion; so that they can be easily detached without altering their form."—[T.]—*Comptes Rendus, 24th April,* 1843.

Passage of two electric currents along the same conductor without interference.—Prof. Morse, in a letter, dated Jan. 17, 1843, writes, that he and Prof. Fisher have discovered that several currents of electricity will pass upon the same wire without interference, either in the same direction, or in opposite directions; and that he has reduced the discovery to practice. The arrangement of his circuits, like Mr. Gassiot's,* resembles the figure ∞; each segment including a cell and an electro-magnet: when both circuits were completed, he found a current in the wire which was common to the two circuits.—*Silliman's Journal.*

An electrical ray has been long known to the fishermen of Cape Cod and New York, under the name of *cramp-fish* or *numb-fish.* Mitchell refers to this species, which he had not seen, but from the description he supposed it to be identical with the European *raia torpedo.* Dr. Storer has lately procured a specimen, and it proves to be the *torpedo nobiliana;* and it exactly corresponds with Mr. Thompson's description, in the fifth volume of the "Annals of Natural History," of a specimen taken on the Irish coast in 1838.—*Silliman's Journ.*

We have just had an opportunity of witnessing Messrs. Elkington's process for depositing metals from their solutions. We will pass over the solutions of the more precious metals, to say a few words on the deposition of zinc. They have succeeded in depositing this metal on iron; by which means, a very effectual coating is provided against the action of the weather. The advantage gained by electro-zincing is that the metal is pure; whereas, in other modes of zincing, the coat obtained consists only of the ordinary zinc of commerce; which, with its impurities, is very effectually corroded. The process, which is now but in its infancy, is spoken of as being about to be adopted for coating the iron of the portable houses which are exported to our foreign settlements. The specimens we have examined promise well for the future success of the art: we shall not fail of communicating to our readers any thing new which may transpire in it as time revolves. The plan of depositing copper, for the preservation of gun-barrels, and other iron-work, is now carried on to a considerable extent at the same works.

* Vide Trans. Elec. Soc. p. 132.

Digitized by Google

THE MIRROR,

Published Weekly, Price 2d. And in Monthly Parts.

THIS popular Periodical to its former attractions has recently added a great variety of Original, Literary and Scientific Papers by eminent writers. It may now challenge comparison with the most expensive Magazine. Of discoveries and inventions the Proprietors are enabled to give the earliest and the best announcements, and all that is most interesting to the admirers of Literature will be found in its pages.

Each Number contains an engraving of the arms, with heraldic descriptions and a notice of the founder of some noble family, illustrated in many cases with authentic facts not to be found in any Peerage extant. These, indexed at the proper time, will form a most valuable work of reference. Diagrams with instructive descriptions are also given, together with pictorial representations of historical events or remarkable buildings, the whole furnishing an Illustrated Miscellany, second to none in interest and variety.

Narratives of recent visits to Norway and parts of France but little known, and the Moon Seeker, a Tale, by the celebrated German writer, Ludwig Tieck, translated expressly for "The Mirror" will immediately appear.

The following are among the numerous laudatory notices which have recently appeared in the Provincial Press :—

"The numbers for April form a part rich in illustrations, and containing more than the ordinary number of original papers. The arms and sketches of the noble families of Norfolk, Shrewsbury, Manchester, and Nelson, form a valuable and interesting portion, while the larger engravings are executed in the nice style which has gained for the *Mirror* its well-earned fame. As a cheap, clever, interesting periodical, the *Mirror* stands unrivalled ; and as it was the first of the twopenny weeklies, so it continues the best."—*Cheltenham Journal.*

"This popular favorite does not grow dull as it grows old : on the contrary, it appears to be more entertaining than ever. It is most judiciously edited."—*Somerset County Gazette.*

"This excellent and cheap publication has been long known and esteemed ; and has been recently much improved. The monthly Part before us contains some good articles, original and selected, and sixteen engravings."—*Bolton Chronicle.*

"Of our old acquaintance, *The Mirror of Literature and Amusement*, we are happy to be enabled to speak in terms of the highest commendation. The work is extremely well conducted. Its low price and the variety and excellence of its matter and illustrations render it particularly worthy the support of the humbler classes of readers."—*Liverpool Albion.*

"This popular old acquaintance continues to be well "got up." Its low price, the variety, excellence, and general interest of its matter and illustrations, render it particularly worthy the support of the humbler classes."—*Sheffield Iris.*

"The *Mirror* is embellished with nearly a score of engravings. We have been much pleased with many of the articles in this number. Altogether, we are bound in fairness to bestow high praise on the talent, care, and taste of the editor of this excellent Magazine."—*Derby Courier.*

Published by CUNNINGHAM and MORTIMER, Adelaide-street, Strand, and may be ordered of any Bookseller or Newsman.

PHILOSOPHICAL APPARATUS.

MAGNETIC Electro-magnetic and Electrical Apparatus, Coils for giving powerful shocks, Improved Batteries, Air Pumps and all kinds of Pneumatic and Optical Instruments made and sold by C. W. COLLINS, Instrument Maker and Accurator by appointment to the Royal Polytechnic Institution, 3, Wardour-street, London ; third door from Oxford-street.

Digitized by Google

Now Publishing in Parts, each complete in itself, Price 1s.

MANIPULATIONS IN THE SCIENTIFIC ARTS.

The following are already published.—Parts I. and II.

ELECTROTYPE MANIPULATION.

By Mr. Charles V. Walker, Editor of the Electrical Magazine.

Twelfth Edition.

*** These Two Parts may be had done up in cloth boards, Price, 2s. 6d.

"This little Manual contains a most complete account of the whole process of Electrotype Manipulation. We have seldom indeed met with a work professing to give instruction in the manipulation of any art or process of manufacture so practically useful as this small volume."—*Civil Engineer and Architect's Journal.*

"A really valuable book, a perfect specimen of the *multum in parvo*."—*British Friend in India.*

Part III.

PHOTOGENIC MANIPULATION,

Containing Plain Instructions in the Theory and Practice of the Arts of *Photography, Calotype, Cyanotype, Ferrotype, Chrysotype, Anthotype, Daguerreotype, and Thermography.*

By George Thomas Fisher.—Illustrated by Wood Cuts.

*** All the Apparatus and Materials described in these Works may be had wholesale or retail of the Publishers, George Knight and Sons, Foster Lane, London, Manufacturers of Electric and Galvanic Instruments, and every description of Philosophical Apparatus.

THE ILLUSTRATED POLYTECHNIC REVIEW,

A Weekly Record of Science, the Fine Arts, and Literature, 4d.; stamped, 5d.

The Parts contain

FINE ARTS.—Portraits and Memoirs of Michael Angelo, Raffaelle, Titian, Leonardo da Vinci, Sebastian del Piombo, Giotto, Cimabue, Baccio Bandinelli, Fra Bartolomeo, Ghirlandajo, Lorenzo Ghiberti, Masaccio, Carlo Maratti, Peter Paul Rubins, Nicolas Poussin.

MEMOIRS on the Theseus, the Apollo Agyieus, the Diana of Ephesus, Dionysos, Hermes, Palladium, Encaustic Tiles in England and Ireland.

ARTICLES on Gwilt's Encyclopedia of Architecture, Whewell's Architectural Notes on German Churches, Ecclesiastical Architecture, Street Architecture, St. Peter's at Rome, Decorated Fountains, the Pnyx at Athens, the Gate of Lions at Mycene, the Cyclopean Arch at Delos, Twerton Suspension Bridge, Kingston Bridge. A series of communications on Anatomy, as connected with the Fine Arts.

TOPOGRAPHY.—PORTUGAL AND ITS COLONIES. — Lisbon, Cintra, Elvas, Fayal, Flores, Pico, Macao.

SPAIN.—Madrid, Cadiz, Seville, the Alhambra.

CHINA.—Hong Kong, Macao, Amoy, Ningpo, Chusan, the Buddhist Worship, Chinese Calenderer, the Emperor, the Soldiery.

THE ROUTE TO INDIA.—Alexandria, Candahar, Jellalabad, Singapore.

NOTICES of Rome and its Buildings, Athens, Mycenæ, Bay of Panama, and Vera Cruz.

TOPOGRAPHICAL ACCOUNTS of Holy Island Castle, Runnymede, Chillingham Castle, Plymouth Breakwater, the Buildings of London, Blenheim Palace, Hampton Court, Hilton Castle, Ford Castle, Bywell Castle, Nutford Manor House.

PORTRAITS.—Pope, Cowley, Watt, Voltaire, La Sage, Columbus, Americo Vespucci, Cortes, Pizzaro, King Edward the Fourth, King Richard the Third, and Queen Anne; Frederick the Great, the Emperor Francis the First, the Empress Maria Theresa, the Emperor of China. Cardinal Wolsey, Duke of Wharton, Marischal Keith, General Seydlitz, General Liethen, Bubb Doddington, Duchess of Kingston, Rob Roy.

London: Published by Henry Renshaw, at the Office, 356, Strand, where Advertisements and Communications are received, and may be had of all Booksellers and Newsmen.

Digitized by Google

ELECTRICAL MAGAZINE.

OCTOBER, 1843.

XIV. *Electro-chemistry; Plating;—Improvements introduced by* M. Ph. MOUREY. From "Les Comptes Rendus," April 3, 1843. No. 14, p. 660.

(TRANSLATION.)

As soon as M. de la Rive had published the result of his researches relative to the application of a precious metal upon another of less value, philosophers and artizans were every where seen occupied, each in his respective sphere, in applying it to manufacturing purposes, or in attaining that perfection in the process, which daily experience proved to be necessary; for the principle, though good in itself, was nevertheless susceptible of great improvements in its practical application.

Mr. Elkington, who was engaged in researches on this subject, more fortunate than the philosopher of Geneva, made use of an alkaline solvent, which indeed M. de Ruolz has likewise employed.

Very shortly after, M. Becquérel communicated to the Academy a process by which, by means of his apparatus, objects, such as filagree work, that heretofore did not appear susceptible of being operated upon, may be gilded and plated. From this period gilding and plating assumed a new character, and the Academy has already sanctioned the result by awarding the Montyon prize to the inventors, MM. de la Rive, Elkington, and de Ruolz. Nevertheless, much was still wanting to plating, inasmuch as the articles, though of a perfect white colour on the removal from the bath, were not long in losing their brilliancy, and at the end of a few days even in becoming of a dirty yellow; if the ordinary means were adopted of putting them in colour, they were altered.

Struck with this untoward result, which tended, if not to

Digitized by Google

destroy, at least to depreciate so perfect an invention, I began to enquire what might be the cause of it, and I found that the yellow colour of the plating proceeded from a cyanuret or a sub-cyanuret, which remained at the surface after the operation; and that light gradually decomposed it.

In this condition, the articles were no longer admissible in the market,—an accident which often happened to me, and caused me considerable loss; I then determined to undertake certain researches, in which I had the good fortune to succeed; and which, at the same time, enabled me to render an essential service to the inventors themselves, by freely communicating to them the fruit of my discovery, with the sole object of being useful to industry, which, having no longer a reason to fear these alterations in plating, may be directed to the fabrication of jewellery and other objects of art, susceptible of being plated.

The following are the means by which I attained the results indicated by the specimens before the Academy.

I thought of employing borax, which I dissolved, and with a thick layer of which I covered my articles; I then submitted them to the action of a temperature, sufficiently elevated to calcine the borax; I employed a muffle to place my articles in, having found this means more sure and less tedious. The temperature, at which I worked, was a little below cherry-red.

This operation over, I cleaned them in water acidulated with sulphuric acid, by leaving the articles to soak in the liquid; the latter operation may be accelerated by means of heat. I then wash the articles, and dry them in hot wood saw-dust; notwithstanding this drying, it is at all times necessary to subject them to heat, in order to drive away the moisture, which they may still retain. The last point is also a master-stroke, the object of which is to give a finer colour; of which the Academy may be convinced by examining my specimens.

Moreover, I think my process so much the more useful inasmuch as it is not necessary that the articles should come out of the silver solution white, the action of the fire giving them that perfect white colour which distinguishes the specimens I have the honour to present. Such is the result of my researches, which experience has justified; for M. Christofle, a distinguished jeweller, to whom I communicated it, as soon as I was certain of success, immediately introduced it in his work-shops.

In conclusion, I should mention that if anything ought to encourage me in presenting this note, it is, without doubt,

Digitized by Google

the courteous bearing of many distinguished philosophers, whom this Academy ranks in its lists, and one of whom, M. Becquérel, in reply to my communication to him on the subject, was kind enough to honour me with a very flattering letter, in which he recognized the value of the means I had employed. [A.]

At a subsequent meeting of the Academy (July 11th) M. Becquérel, in the name of "himself and MM. Dumas and Héricart de Thury, reports in reference to M. Mourey's process, as given above, for the treatment of electro-plating:

"The method of which we have just spoken is very rational; for, in addition to the borax decomposing the subcyanuret of silver, it also dissolves the oxides which may be present on the surface of the silver, without affecting the latter."—[Ed.]

XV. *Addition to a Memoir entitled, "On the Chemical Action of a Single Voltaic Pair, and the means of augmenting its Power."* Extract of a letter from M. A. DE LA RIVE to M. ARAGO. From "Les Comptes Rendus," June 12, 1843, No. 23, p. 1283.

(TRANSLATION.)

ON my return to Geneva, I found the *Compte Rendu* of the sitting of the Academy of May 15th, in which mention is made of an observation by M. Bouquillon,* which has reference to the communication that I had the honour of making to the Academy, the 17th of April last. M. Bouquillon remarked that the decomposition of water may be easily obtained by making use of the apparatus which I have named the *voltaic condenser*, by means of single pair requiring the use of only one liquid. I have myself recognized this fact on repeating at London, with Mr. Faraday, some of the experiments reported in my Notice; and No. 8 of *Archives de l'Electricité*, which has just appeared, contains† at the end of this notice the following postscript:—

"Since I read to the Academy of Sciences the preceding notice,‡ I have had the opportunity of repeating at London, with Mr. Faraday, some of the experiments related in it. I

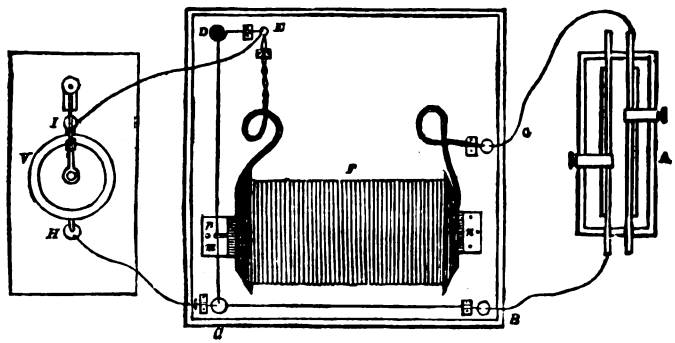
* Vide Elec. Mag. p. 40. † Vide Les Archives, p. 172, June 2, 1843.
‡ Vide Elec. Mag. p. 30.

Digitized by Google

have found that a common pair of *zinc* and *copper*, or *zinc* and *platinum*, placed in sulphuric acid diluted with water, is able to decompose acidulated water, by the introduction of the voltaic condenser, as well as a pair of Grove's or one of Daniell's; the decomposition is merely less energetic. To render it sensible, it is better to use a voltameter with platinum wires, instead of one with plates. Thus, by passing through the pair, in order to increase its action, the induced current, produced by the pair itself, it is not necessary that there be two chemical actions in the pair in order to decompose water, as is necessary when there is no induced current, and when the current of a single pair is made to pass directly through water."—[A.]

XVI. *Description of the Voltaic Condenser.** By M. DE LA RIVE. From "Archives de L' Electricité," No. 8, p. 173. June 2, 1843.

(TRANSLATION.)



A, the pair.

B and *G*, the extremities of each of the conducting wires of the pair, which are placed in cups of mercury, or are connected at *B* with the extremity of a wire *B C*, and at *G* with the extremity of a wire covered with silk.

C, small capsule of amalgamated copper.

C D, metallic rod furnished at *D* with a spring, that keeps the end at *C*, which is bent vertically downward, in contact with the bottom of the capsule *C*.

* Vide Elec. Mag. p. 38.

Digitized by Google

D E, conducting wire, which connects the rod *D C* with the end *E* of the wire covered with silk.

F, helix formed of wire covered with silk rolled round a bobbin; *E* and *G* are the two extremities of this wire.

m n, cylinder of soft iron placed in the interior of the bobbin.

p, small attached piece of soft iron, which is attracted by the extremity *m* of the cylinder of soft iron, when the latter is magnetized by the current.

H and *I*, the extremities of the conducting wires, *C H* and *E I*, which serve to include a voltameter *V*, in the circuit.

At the moment when the circuit is closed, the current circulates in *B C D E G;* the piece *p* is instantly attracted, because *m n* is magnetized; but the circuit is immediately interrupted at *C*, because the rod *D C*, the bended extremity of which touches the bottom of the capsule *C*, is raised. This interruption of the circuit gives rise to an induced current in the wire of the helix *F*, which is determined in the same direction as that of the pair. On the other hand, a new circuit is formed whilst the rod *D C* is raised; this circuit, in which the pair *A* is included, is the circuit *B C H I D E G A;* the voltameter *V*, is now seen to form part of this circuit, and it is traversed at once by the induced current, and by the current of the pair reinforced by the passage of the induced current through the pair. But as soon as the circuit is broken in *C*, the soft iron *m n* ceases to be magnetized, or at least is very feebly so, because the voltameter is in the circuit; the attached piece *p* being no longer attracted, the rod *D C*, subject to the action of the spring *D*, immediately falls, and the circuit is no longer interrupted at *C*.

The current of the pair again commences to circulate by *B C D E G*, and the same series of phenomena occur. It is necessary that the power of the spring *D* and the distance of the piece *p* at the lower part of the extremity *m* of the soft iron be so combined that the oscillatory movement of the rod *D C* should be executed easily and very rapidly; by a little adjustment the apparatus is very readily placed in the conditions most favourable to this effect.—[A.]

Digitized by Google

XVII. *On Induced Currents, derived from the Action of the Earth.* By MM. PALMIERI and SANTI LINARI. (Extract from a letter from M. Melloni to M. Arago.) From "Les Comptes Rendus," June 26, 1843, No. 25, p. 1442.

(TRANSLATION.)

WHEN Mr. Faraday discovered the electric induction excited by the brisk approach or recession of a magnet and copper spirals, or *vice versâ*, he immediately foresaw that the same spirals turned rapidly, in the plane of the magnetic meridian, from one to the other direction of the dipping needle, would be traversed for some moments by electric currents; and his anticipations were effectually realised when he had placed the extremities of the aforesaid movable spirals in connection with a very sensible galvanometric multiplier. This beautiful experiment was repeated by a host of philosophers, and especially by MM. Nobili and Antinori, who succeeded in tracing it to the simple principle of the electric induction of magnets. Endeavours were made, in all directions, to increase the intensity of these electric currents, which were due to the magnetic force of the globe, in order to obtain other effects than the mere deflection of the magnetic needle. Not any of these attempts were crowned with success. The first successful results in this class of researches are, unless I am deceived, those which I have the honour of announcing to the Academy.

After having made many variations in their apparatus, MM. Palmieri and Linari determined on the following arrangement: they constructed a kind of pile, composed of a certain number of elements, formed of the ends of gun barrels, separated from each other but arranged parallel, and enveloped in a long copper wire covered with silk, which, instead of concealing the barrels in their entire length, left a fifth part exposed at the two extremities. These exposed portions are stopped by cylinders of soft iron; the wire forming the superposed convolutions of each barrel returns in a direct line towards its commencement, at the end of each of them; it passes from one to the other element, by returning always in a direct line to recommence its convolutions, and thus forms several concentric or parallel sections of a single kind, either a *right* or a *left-handed* spiral. These elements, ten in number in the battery presented to us, are six decimetres [24 in.] long, and are fixed by their middle, at a reciprocal distance of 0·10 mil. to 0·13 mil. (about $\frac{1}{2}$ an inch), on the same wooden axis, which rests by its two extremities on two pivots, and

Digitized by Google

carries on one side two metallic pieces exactly like those of Clarke's apparatus, which pieces are intended, as in the aforesaid apparatus, to receive the two extremities of the copper spiral.

The elements are adjusted according to the magnetic meridian, and a very rapid rotatory motion is given to the axis by means of a system of wheels and cords, like those of a great turning lathe.

It is scarcely needful to say that this particular kind of pile, called by its inventors the *magnet-electro-telluric* battery, gives to the magnetic needle of galvanometers much more powerful deviations than in Faraday's experiment. I pass on then at once to two new facts produced by terrestrial magnetism. These two facts are the shock, and the decomposition of water.

In order to obtain the shock, two copper wires are used, which are terminated by cylinders of the same metal, and are held in the hands moistened with acidulated water. The shock is rather weak, generally sensible in the joints of the fingers only, but perfectly distinct; some nervous persons have even felt it as far as the wrist. To give an exact idea of it, I may add that it appeared to us exactly like the shock given by the armature with the larger wire in Clarke's most powerful machines, which are, without any doubt, those made by M. Ruhmkorff.

The decomposition of water is obtained by making the extremities of the pile communicate with two very fine iron wires, wound into a helix, and introduced together into the same bell-glass, filled with acidulated water, and inverted in a vessel containing the same liquid. As the metal of which the immersed helices are formed, is highly oxidizable, and as, by the nature of the apparatus, the electric currents, which are excited, take alternately the two opposite directions, both helices are soon seen to be covered with the same quantity of gaseous dew, which increases by degrees, quits the wires and collects in the upper part of the bell, in sufficient quantity for analysis, and for being recognised as having all the characteristics of hydrogen.

The phenomenon of decomposition would, without doubt, become more satisfactory and complete, if we could obtain the two elements of water, by means of gold or platinum wires. It would be also desirable that the shock should have a more decided character. I think both effects might be obtained by means of a telluric pile composed of a large number of soft iron barrels, covered with much finer copper wire than that employed by the authors. It even appears probable that

Digitized by Google

MM. Linari and Palmieri will succeed, by means of their apparatus, in heating wires and in producing electric sparks, by multiplying the elements, or by employing copper wire of greater thickness, and uniting the free ends, so that all the homologous extremities, superior and inferior, should communicate together, and thus form a single element, the wire of which would have a section equal to as many times its own area as there are elements in the pile.

The Royal Academy of Sciences of Naples, on approving of the favourable conclusions of my report, have decided to grant a sum of 200 ducats (36*l.*) to MM. Linari and Palmieri, in order that they may continue their researches on the means of augmenting the intensity of the electric effects developed by the magnetism of the terrestrial globe.—[A.]

XVIII. Extract of a letter from M. Masson to M. Arago, "*On the Formation of the Images of Moser.*" From "Les Comptes Rendus," June 26, 1843, No. 25, p. 1452.

(TRANSLATION.)

. . . . The interesting experiments of M. Riess, (*Répert. de Phys. de Dove et Moser*, t. 6, p. 180), and those of M. Karsten, (*Ann. de Pogg.* t. 8, p. 115),* confirm me more and more in my opinion, [of the electrical origin of the durable impressions observed in watch cases], and I made the experiment, which I had the honour of communicating to the Academy, and which must serve as the starting point to a work, the object of which is to throw light upon the following questions: —In all the experiments of M. Daguerre, and M. Moser, is not the fixation of the vapours preceded by an electrical condition of the surfaces? Do not light, heat, *electricity*, by acting on all bodies, produce the same final state which gives them the property of fixing vapours, either physically or chemically? Is not this final state an electro-static state?

In which case, would not the chemical action be secondary? The electric conductibility of bodies being only relative, I was naturally led to seek whether, by suitably modifying the intensity of the electric action, I might not succeed in producing all Moser's impressions by electricity.

I commenced my researches by placing myself in circumstances, which left no doubt as to the nature of the action.

* Vide Elec. Mag., p. 5.

Digitized by Google

After many attempts I confined myself to the following method of operation:—

I take for a condenser, Daguerréotype plates out of use, which afford a perfectly plane surface. I melt on these plates a layer of insulating substance, the thickness of which varies from $\frac{1}{2}$ to one millimetre. I employ the substance constituting the electrophorus, sealing-wax, yellow wax, gum lac, &c.

After having placed on the insulating layer the medal that I wish to reproduce, which is in most cases merely a piece of money, I electrize it in the following manner:—

Connecting either the coin or the metal plate with the earth, I throw a spark from the electrical machine on the one which is free; at other times, I put it directly in contact with the machine, and turn the plate several times according to the insulating power of the resin; finally, and this succeeds very well, after having connected one of the conductors of the condenser with the outer coating of a Leyden jar, I discharge the inner coating on the other. The intensity of the discharge must vary with the thickness of the insulating plate and its conductibility, or rather its power of induction. The spark always darts between the two coatings, which seems to indicate that, in this case, there is no transmission of fluid through the insulating layer.

When the medal to be reproduced is itself formed of an insulating substance, glass, for example, it is better to place it directly in contact with the machine. I have thus produced very beautiful impressions with glass seals.

The plate being electrized, to make the impression appear, very fine powder must be projected on its surface, which I accomplish by means of the bellows employed in producing Lichtenberg pictures. I had at first employed two powders, but the images are clearer with one only. I have hitherto only operated with red lead, but I have no doubt that equal success may be obtained with every kind of dust, for example, that of silica, licopodium, &c. The following phenomena present themselves: if the medal receives positive electricity, the parts of the insulating layer corresponding to the reliefs are filled with dust; I shall call this image positive; when, on the contrary, the medal receives negative electricity, the parts corresponding to the relief, remain unaffected.

It is however useful to remark that the effect may be reversed, according to the nature of the insulating layer, its thickness, and the electric nature or condition of the former. If the impressions obtained by Moser, and the Daguerrien images have any relation to electrical images, will not an ex-

STANFORD

Digitized by Google

planation of that variation of images, which are positive or negative, according to the circumstances under which we operate, be found in the preceding facts? By electrizing vapours, could we not obtain, at pleasure, positive or negative images? I have not as yet been able to solve the latter question.

After having obtained electric impressions on resins, I attempted it on prepared Daguerréotype plates. A medal, on such a plate, was submitted to the action of the pole of a dry pile for one minute. The impression was rendered evident by mercury, and I have the honour of forwarding it to you. I cannot, at the present moment, deduce anything from this experiment, repeated several times with different success, because I had immediately obtained the same impressions without a dry pile, by leaving, it is true, the medal a little longer in the experiment. The sensibility of the film of iodine, the difference of temperature between the plate and the medal, have such an influence, that in order to draw conclusions, we must operate with or without electricity under circumstances always identical. I have exposed to the sun iodized plates, on which I had placed medals, until the film of iodine became black. Some were electrized by a dry pile, others underwent no action of the electric fluid. The former gave positive images, the latter negative.

Finally, I attempted to fix the electric impressions on the plates of resin, and succeeded by slightly warming the metallic plate, which served them as a support.—[A.]

Note.—M. Morren writes to M. Arago,* in reference to the experiments here described by M. Masson, that "the fidelity of the impression depends on the thickness of the coat of resin," diminishing as the thickness increases; which circumstance appears to him "of great importance in explaining the Daguerréotype pictures, in which the sensible film is of a thickness which has been approximately fixed, by M. Dumas, at less than a millionth of a millimetre." He says,—

"The light, falling on iodide of silver, would determine a chemical action proportionate to the intensity of the light; this action would develope electricity in the sensible film, which would then fill the place of the resin in the preceding impressions, and the mercurial vapours would go and adhere against the electrified parts, through the influence of the iodide of silver, exactly as does the red lead, thrown on resin by the bellows of Lichtenberg."

* Vide Comptes Rendus, July 10, 1843, p. 87.

Digitized by Google

XIX. *Memoir on the Application of the Oxides, and of Metals upon Metals.* By M. Becquerel. From "Les Comptes Rendus," July 3, 1843. Deuxième Semestre, No. 1.

(TRANSLATION.)

§ 1. On the employment of the oxygen gas apparatus for the formation of hydrate of peroxide of lead, and the application of the oxides upon the metals.

General Considerations.

I have been long engaged in the endeavour to prove, by the evidence of a large number of new facts, that, in order to advance the physico-chemical sciences, we cannot avoid making the action of affinities and that of electric forces advance at the same pace. Experience every day proves to us most surely that this simultaneous action of two forces, which are inseparable, and one of which can serve to reproduce the other, and *vice versâ*, is naturally fitted to extend the domain of chemistry and its application to the arts. The results contained in the present memoir, the first part only of which I communicate to the Academy to-day, will furnish new proofs of this, and they will at the same time demonstrate that metallic contact, not followed by a chemical action, is absolutely without influence over electro-chemical effects; and that no farther attention need be paid to it, for fear of our being delayed by the discussion of principles, which leave the partizans and the adversaries of Volta's theory in the same circle of ideas, without any real advantages to science being the ultimate result.

Some years ago I described an electro-chemical apparatus, by the aid of which oxygen gas might be obtained in considerable abundance, and in a short space of time. This apparatus, which serves as a type to constant batteries, consists of a vessel filled with nitric acid, in which is placed a glass tube, closed at bottom with clay that is retained by means of a piece of linen properly tied, and filled with a concentrated solution of potash; and of two plates of platinum immersed, one in the acid, the other in the potash, and connected by means of a platinum wire, the ends of which are twisted together. As soon as connection is made, abundance of oxygen gas is liberated on the plate contained in the solution of potash; this effect is due to the action of the current, that arises from the combination of the acid with the potash, which action is exalted in proportion as the tamping of clay is thinner. Plaster, mixed for the purpose, may be substituted for clay.

Digitized by Google

At the time I made this apparatus known, I stated that it might be usefully employed in a variety of cases, and especially when the object was to present oxides in their nascent state to other bodies with which they were required to be combined. My anticipations have not deceived me, as the Academy will have the opportunity of judging by the experiments, the results of which I am about to have the honour of laying before them.

In this apparatus the nitric acid, and probably the water, are decomposed; the results of the decomposition are:—oxygen in the tube where the potash is, and nitrous acid around the platinum plate which is in the nitric acid. If the decomposition of water contained in a separate vessel is desired, we have only to replace the platinum plate immersed in the potash, by a plate of zinc, and to attach to this a platinum wire, at the end of which is fixed another plate of platinum; and also to place another plate at the free end of the second wire. Water is decomposed as soon as the two plates are immersed in it: the plate connected with the metal, which is in the potash, is the negative, the other the positive pole; the liberation of gas on each is abundant.

What occurs when zinc is substituted for platinum is, that the former, being oxidized by the reaction of the alcaline solution upon it, assumes the negative electrical condition; moreover, by the reaction of the acid on the alkaline solution, the latter acquires negative electricity, which it transmits to the zinc plate; so that when the circuit is closed, the current resulting from the reaction of the two liquids on each other, is added to that derived from the oxidation of the zinc; but as this double effect is produced without the intervention of a new pair, and consequently without there being a new alternation, it follows that the current has a more energetic decomposing force than in the former case; and thus water is abundantly decomposed in a vessel separated from the apparatus, although forming part of the circuit. It can be proved, however, that water is in like manner decomposed in the separate vessel, by using the simple apparatus of platinum plates alone; for this purpose, advantage must be taken of the property possessed by solutions of salts of lead to be decomposed, when in contact with the positive plate of a voltaic apparatus. In this case, the oxide of lead, passing to the maximum of oxidization, separates from its acid and is deposited on the plate. If a salt of lead is dissolved in the water which is to be subjected to decomposition, the very feeble quantity of oxygen, which arrives on the positive plate, in most cases prevents all further decomposition, as M. de la

Digitized by Google

Rive has recently proved; but here the gas combines with the protoxide of lead, whence results a peroxide that is precipitated, so that the cause, which opposed the circulation of the current, no longer exists. The brown tint, assumed by the plate, necessarily indicates the decomposition of water: a solution of protoxide of lead, in potash mixed with water, is sufficient for this purpose. We are hence led to examine what takes place in the simple apparatus, by substituting the alkaline solution of lead for the solution of potash; and, for more simplicity, let us replace the concentrated nitric acid by a concentrated solution of sulphate of copper, forming communication between the two liquids by means of platinum plates; in a short time, according to the facility with which the current passes, the platinum plate immersed in the potash becomes black, and is covered with an excessively thin film of peroxide of lead; whilst the plate, immersed in the sulphate of copper, is not covered with copper in a metallic state. Hence it follows that the current produced by the reaction of sulphate of copper on potash, by the intervention of moist clay, decomposes water,—that the oxygen liberates lead in the state of peroxide, whilst the hydrogen transforms the sulphate of deutoxide of copper into sulphate of protoxide, since no hydrogen is disengaged, and no copper is for a long time precipitated on the negative plate. If nitric acid is employed instead of sulphate of copper, the effects change as will be seen.

Of the hydrate of peroxide of lead.

The tube is filled with a concentrated solution of potash and protoxide of lead; nitric acid is left in the vessel, and the circuit is completed with the two plates and the platinum wire. The nitric acid is decomposed; oxygen is carried to the plate contained in the alkaline solution, and, instead of being liberated, it reacts on the protoxide of lead, and no longer makes it pass to the state of puce peroxide, but rather to that of the yellow peroxide and with the formation of scales of anhydrous peroxide, according to the intensity of the current, whenever the nitric acid is concentrated, and the reaction of the acid on the alkali is energetic, a condition which is obtained by employing a very thin clay diaphragm. The precipitate, at first of a beautiful canary yellow, after having been washed and dried in the air, acquires a dull ochre tint; if dried in vacuo, it always remains yellow; but its tint is not so beautiful as when it is formed in potash, out of contact with light; it would even appear that, at the early period of its formation, light acts on it. When very dry, if exposed to the

STANFORD

Digitized by Google

action of heat, it begins to lose its yellow colour at about 30 degrees; and, if the elevation of the temperature is continued, it is changed into the puce peroxide of lead. When heated in a tube, the sides become covered with drops of water; hence the new compound cannot but be an hydrate of peroxide.

The results of analysis leave no doubt on this point. 0·179 gr. of the yellow precipitate, dried with care in vacuo, were strongly heated to change them into puce peroxide; after which the weight was only 0·165 gr.; so that 0·014 gr. of water were lost. The 0·179 gr. of the yellow precipitate must have contained 0·165 of peroxide of lead, and 0·014 gr. of water. Now, as the atomic weight of the peroxide is 1494·5, and that of the water 112·50, it follows that 0·165 gr. and 0·014 gr. represent one atom of peroxide of lead, and one atom of water. Such is the composition of the yellow compound thus obtained, which is an hydrated peroxide of lead not yet described in chemistry.

The action of light appears to cause this compound to lose its water of crystallization, in order to change it into anhydrous peroxide.

To procure a certain quantity of this compound, the place of the tube must be supplied by a cylindrical vessel of unglazed porcelain in which the solution of potash and protoxide of lead is placed. The action may be facilitated by the use of one pair; but this must not be exceeded, if we wish to avoid the formation of a great quantity of anhydrous peroxide; we must repeat, that an indispensable condition to the success of the experiment, is to employ concentrated nitric acid, and likewise a concentrated alkaline solution of protoxide of lead. In the sequel we shall see how anhydrous peroxide of iron may be procured: with respect to the hydrate of peroxide of manganese, the experiments undertaken for the purpose of obtaining it have been without success; but these experiments have led me to the solution of another question, which may perhaps not be without interest in the arts which are devoted to covering metals with an unalterable coating.

On the application of oxides with adhesion to metallic surfaces.

If the application of metals on other more oxidizable metals, in order to preserve the latter from the influence of atmospheric agency, has long occupied our minds; and if satisfactory results have been obtained in certain cases, what would not be the advantages if for the less oxidizable metals were substituted unalterable oxides, such as the peroxides of lead and

Digitized by Google

iron, especially the latter, which is so fixed as to resist the action of a very elevated temperature? This question may now be solved by aid of the apparatus described above, and by following very nearly the same mode of experiment as for obtaining the anhydrous and the hydrated peroxides of lead. But, before pointing out the mode of operation, I will recall to mind that in the experiments I made for collecting all the lead and manganese found in a solution, without any trace remaining, the peroxide of each of these two metals was deposited on the positive plate in films formed of particles very slightly coherent, and not having any adhesion to the plate, which must be of platinum or gold in order to avoid giving rise to new reactions. To resolve the question I had proposed, it was necessary that the adhesive deposite of peroxide should take place, not only on gold, platinum, and silver, which have no need of being preserved, but even on copper, iron, and other metals in more common use, which are often exposed to all the variations of the atmosphere. From the effects obtained in the first paragraph of this memoir with solutions of protoxide of lead in potash, I was naturally directed to alkaline solutions; I had no other choice than of solutions in potash or in ammonia. Now, among the oxides which potash dissolves we will notice protoxide of lead, oxide of zinc, protoxide of tin, and chromic oxide, &c.; while ammonia dissolves protoxide of iron, oxides of zinc and cadmium, the binoxides of copper, the oxides of nickel, cobalt, &c. I only turned my attention to solution of protoxide of lead in potash, and that of protoxide of iron in ammonia, in order to render evident the principle of the adhesive fixation of oxides upon metals; and to point out the path to be pursued to apply it to other oxides.

We will begin with the *potash solution of lead.* 200 grammes* of caustic potash were dissolved in a retort in two litres† of distilled water; 150 grammes of litharge [protoxide of lead] was added; it was boiled for half an hour; the solution was allowed to settle; after which a cylinder of unglazed porcelain was taken, and was filled with the solution diluted with its volume of water. The cylinder was placed in a vessel containing water, acidulated with about $\frac{1}{20}$ its weight of nitric acid, in which was placed a platinum plate connected with the negative pole of an ordinary constant voltaic pair. The positive pole was connected with the article to be covered with protoxide. Let us suppose a plate of iron, and observe what will happen. The plate, having been cleaned by the dry process, and smoothed with the file and pumice-stone, was

* A gramme=15½ grs. † A litre=61 cub. in.

Digitized by Google

plunged into the solution. A great quantity of hydrogen gas was immediately liberated on the platinum plate, in consequence of the decomposition of the water and the nitric acid. The oxygen, on being liberated at the positive pole, instead of oxidizing the iron, changed the protoxide into the peroxide of lead, which, being attracted to the same pole on account of its negative state, is deposited on the iron, and adheres to it. A few minutes are sufficient for the plate to be covered with peroxide of lead, of a black colour, having a light brownish tint. The article, on being drawn out, and dried in saw-dust, supported the polish of English rouge; and the surface acquired a black leadish appearance with a tolerable polish. When a copper plate was used, instead of one of iron, the same effects of colour were presented; the adhesion was not quite so firm; but this was probably due only to the condition of the surface. On silver, on plate, and especially on objects whose surface is slightly rough and covered with asperities, the adhesion is stronger and supports the burnisher. The colour is jet black. Cut leaves have been prepared in this way, and the nerves have been burnished without the peroxide being detached. After twelve hours' experiment, when the solution is not changed, and when very little protoxide of lead remains, the metallic surface is covered with a precipitate of peroxide of lead, which has but little adhesion, and the effect of which is such that it has the appearance of a beautiful black velvet. A little brass bust, when covered with peroxide of lead and burnished, presented the appearance of a beautiful bronze. So long as hydrogen gas is liberated on the platinum plate, the operation goes on well; when the liberation ceases, it must be remedied by immersing the platinum plate in nitric acid to clean its surface; or by seeking in the voltaic pair the cause of the diminution of the liberation of hydrogen. This diminution may proceed from divers causes: from endosmose having introduced protoxide of lead into the vessel containing the acidulated water, whence is produced nitrate of lead, which is decomposed; or else the current diminishes in intensity. I wished to examine to what extent it was possible to deposite peroxide of lead on a pistol barrel, the surface of which had been cleaned with the file and pumice-stone. The results were as satisfactory as could be expected; the surface of the barrel acquired, under the leather and English rouge the brilliancy of the plate of iron. Experiment will soon prove whether the barrels of fire-arms and other iron articles in constant use, may be durably preserved by this means.

We have seen above that the surface of the iron acquired a

Digitized by Google

black appearance. If the action is continued for a short time only, the colour of the precipitate is ochre yellow, a colour which gets gradually deeper, and to which another tone may be given, as will be seen in the sequel. With copper, the surface, a few moments after immersion, sometimes presents rainbow tints, which are due to thin deposites, and from which jewellers may perhaps derive some advantage. Let us pass on to the deposition of peroxide of iron on iron and steel articles.

The most simple means of preparing the ammoniacal solution of iron, which must also be placed in an apparatus like that above described, is to make by heat a solution of protosulphate of iron; to place it under an exhausted receiver, in order to expel the air it contains, and then to preserve it in a closely stopped vessel. A certain quantity of this solution is poured into the porcelain cylinder, and into it is poured some ammonia also deprived of air, in quantity a little more than sufficient to dissolve the protoxide of iron. The article to be covered is then placed in it, and is connected with the positive pole of the pair; the solution is stirred with a tube, and the cylinder is closed to shelter it from the action of the oxygen of the air, which would tend to make the protoxide pass into peroxide. Notwithstanding all these precautions, some green oxide is always deposited, which it is impossible to avoid. As soon as the circuit is closed, there is liberation of hydrogen on the platinum plate; and the oxygen, on being liberated on the article in the ammoniacal solution, peroxidizes the iron, which is deposited with adhesion, on the same principle as that which influences the deposition of peroxide of lead on the copper plate, that is to say, because the protoxide of iron, acting the part of acid in respect to the alkali, is attracted by the positive pole. But all the metals are not fitted to receive similar deposites: those whose oxides are soluble in ammonia, must be excluded, such as plated and gilt copper, because the liberated oxygen oxidizes the copper either directly or through the coating of silver or gold, and the oxide of copper, dissolving immediately in the ammonia, it is no longer possible to obtain the deposite. This is not all; a great part of the oxygen, being employed to oxidize the copper, cannot re-act upon the protoxide of iron; but this is not the case with iron and steel, for they become covered with an adhesive coating of peroxide of iron. A few minutes are sufficient to give the deposite a brownish red colour, having somewhat the aspect of precipitated copper. The deposite takes a polish when rubbed with the leather and English rouge. When the surface has been properly prepared

Digitized by Google

beforehand, the deposite may be subjected to the steel burnisher. A pistol-barrel, a steel tool and various articles were covered with peroxide with equal success. The brownish-red colour of the deposite is always the same, when the plate remains immersed for a short time; but, if the operation is continued, some remarkable effects occur, which I will describe somewhat in detail, because they bear a relation to the different tints assumed by peroxide of iron, when more or less calcined. Sulphate of iron is known to give by calcination, a beautiful red colour, which becomes deeper when it is derived from the persulphate of iron, and of a brownish black, when prepared by means of deutonitrate of iron, whilst with protonitrate, at a moderate calcination, a deep violet colour is obtained, which painters term *violet of Mars;* if the heat is still further raised, the ordinary red colour of the peroxide is obtained. This play of colours cannot be attributed to the chemical composition of the oxide, for the quantity of oxygen is the same in all the oxides. The molecular arrangement seems the only means of explaining it; but as yet this is only supposition. Now, as may be seen by a glance at the plates I present to the Academy, the same tints are found in applying the peroxide of iron, when working with a single constant pair, excited with moderately acidulated water. In the first instance, the deposite has a red colour; its tint gradually deepens, and, after some hours, it becomes the deep violet constituting the violet of Mars of the painters. With two or three pairs, it gradually turns black. The adhesion of the peroxide diminishes, and there is a point at which the deposite is quite black, when there is scarcely any adhesion. The red deposites are unalterable in the air, whilst the deep deposites are gradually hydrated and change into hydrate of peroxide of iron, having no longer any adhesion. Now, what takes place in continuing the operation? There is a superposition of new deposites,—a transfer of a greater quantity of oxygen:—to these two causes then must be attributed, not only the changes of colour, but also the changes in the state of aggregation of the deposited particles. It might even happen that all these coloured deposites, presenting the same appearance as the peroxides obtained by calcination, were combinations of peroxide and protoxide, which would not form until some time after the commencement of the experiment, and the existence of which would be but of short duration. The super-position of the deposites may also greatly contribute to deepen the tints; but this is not the influential cause, because there is a molecular change.

The observations I have just given must be borne in mind

Digitized by Google

by those who undertake the application of the pr nciple which I have now made known, as the red deposite is formed in a few minutes, the chance of obtaining the black deposites, which have little or no adhesion is not incurred.

Hitherto temperature has not been considered, or at least the experiments are supposed to have been made at the ordinary temperature; but, if the operation is carried on at about 25 degrees, as I have often had it, the deposites are fixed more firmly, because the dilatation, which the parts undergo, permits the molecules of the peroxide either of lead or iron to arrange themselves in the superficial interstices. It is very manifest that the tints may be varied *ad infinitum;* for example, films of various thicknesses of peroxide may be deposited on gold or silver, and thus agreeable tones may be obtained. It is probable that other oxides may be deposited on metals; but in my experiments I confined myself to two.

I think I ought to offer a few further observations, which may not be without use.

It will be remembered that I employed a vessel filled with acidulated water, in which the diaphragm containing the alkaline solution was placed; would it not be possible to do without the diaphragm, and to operate at once on the alkaline solution by taking a sufficient number of constant pairs? This could not be done, because, as the deposite takes place at the positive pole, a portion of the metal would be deposited on the negative plate, so that the solution would soon contain no more metal. In truth, this inconvenience exists, but in a less degree, in the simple apparatus, in consequence of the effects of endosmose, which transport oxide of lead into the acidulated water; but this may be in a great measure remedied by using only one liquid: in this case, the vessel is filled with the same alkaline solution, minus the metal that is contained in the diaphragm; but then a greater number of pairs are required, because a liquid for furnishing oxygen, so readily decomposable as nitric acid, is no longer present.

The alkaline preparation is very important; I have nothing to add to what I have formerly stated concerning the solution of protoxide of lead in potash. With respect to the ammoniacal solution, I will mention a few precautions to be taken to prevent its being rapidly decomposed; and, in order that it may be very clear, ammonia, as concentrated as possible, is placed in a well stoppered vessel, and protosulphate of iron, deprived of air, is poured in until a precipitate is formed; the vessel is closed, the precipitate is allowed to settle, and there results a very clear solution of iron, which may be preserved for any length of time.

Digitized by Google

Cleaning by the dry process is without doubt preferable for the application of metals, to cleaning by the wet process; but as the fatty matters which sometimes adhere to the surface of iron, in consequence of the contact of the fingers, affect the deposite, it is advisable to pass the articles into highly concentrated sulphuric acid, and to wash them in a bath of potash before placing them in the alkaline solution. The articles might be merely left immersed for some time in a bath of concentrated potash, because this bath preserves the iron from oxidation; by following this plan it has sometimes happened that I have withdrawn articles covered with peroxide, that resisted the action of diluted sulphuric acid; which is sufficient to show that they would not have been affected by atmospheric influence.

Although everything leads us to believe that we shall be able to apply to the arts the processes I have now described for depositing peroxides of lead and iron on metals in daily use, in order to preserve them from alteration by the action of exterior agents,—deposites which cannot fail of producing good effects on account of the fixed character of these oxides, especially of the peroxide of iron, nevertheless I am far from thinking that no more researches are required for rendering the process available. I know by experience that there is a wide demarcation between theory and practice; my object in this Memoir has been to make known the principles, leaving to individuals the task of applying them. I have simply wished to prove that the thing was possible. The different articles that I submit to the Academy, will show the foundation on which my assertions rest. Among these articles are several flowers, all the parts of which have been covered electro-chemically, some with gold, others with silver, with peroxide of lead, or peroxide of iron in all their varied shades, the whole arranged with taste by M. Mourey, who is well known to artists, and who has lately discovered a very simple method of preserving electro-chemical plating from the alteration it experiences by contact with light,* when it has not undergone any preparation, and thus to preserve all its brilliancy.

§ II. On the electro-chemical application of metals on metals.

On Adhesion.

The application of oxides, and even of metals on metals, with adhesion, depends not only on the state of the surfaces, but also on the solutions and on the intensity of the current

* Vide Elec. Mag., p. 75.

Digitized by Google

which decomposes them; the examination of all these causes is then of very great interest at the present moment, when all minds are directed towards these applications; with this motive in view, and in order to complete the subject which I have just had the honour of laying before the Academy, I take the liberty of adding to the present communication the result of my observations in this examination.

Experience proves that in general the adhesion of the oxides and of the metals, gold, silver, copper, and lead, on metals, is greater as the intensity of the current is less, within certain well-known limits, and as the solution is less concentrated. Such is the proposition that I am about to develope.

We know that to a certain point currents of feeble intensity produce a firm adherence, while with energetic forces the deposites become less and less coherent. When the deposite goes on very slowly, the molecules crystallize quietly; the body is built up according to the laws of crystallization; whereas, when the intensity of the force is increased, the crystallization becomes more tumultuous and confused, and the result is that the deposite is composed of particles, which have little or no mutual adhesion.

Four or five years before gilding and galvanoplastic were thought of, during the electro-chemical treatment on a large scale of the ores of silver, copper, or lead, I sometimes obtained very adhesive deposites of these metals on bodies placed to collect them, effects which I did not make known in the various public lectures, wherein I gave a general idea of the processes employed; because I reserved the disclosure of all the particular facts for a work which will soon appear. These deposites constituted true platings, and leadings; and I then recognised that the adhesion of lead, copper, and silver, was stronger as the solutions were more diluted and the current feebler; and, be it observed, these observations are dated eight years ago. The adhesion of lead on large plates of copper was so great, that cutting instruments were obliged to be employed to remove it; and even then it was not accomplished without cutting into the copper; so that it might be said that there was really a combination of the two metals in contact. All who have followed my experiments, and I may mention particularly M. Saint-Clair Duport, were witnesses. Well, in the electro-chemical gilding experiments, in which I have been engaged, after MM. de la Rive, Elkington, and de Ruolz, a like effect always occurred. Unfortunately, the principle I have laid down cannot be put into practice, because celerity and economy are requisite in the arts. Nevertheless, one useful consequence arises from my

Digitized by Google

experiments; it is that by employing an energetic current, adhesion is lost, and the gilded and plated articles are of inferior quality as regards durability.

It cannot be said that in electro-chemical gilding and plating, as practised at the present period, there is combination; nothing beyond an effect of aggregation is produced, and a state of cohesion that may always be overcome by physical forces, which does not occur in chemical effects; moreover, the thicker the deposited coat of metal is, the greater the difference of dilatation between the metal which receives the deposite and the deposite itself, the more will variations of temperature tend to separate them from each other; because the resultant of the effects of dilatation is more considerable as the quantity of deposited matter is greater.

There are also many other causes which tend to produce this effect: particularly the mode of cleaning which is adopted in the new methods of gilding on copper. This preparation consists in plunging the copper articles, before their immersion into the gold bath, into one or more mixtures of concentrated or diluted acids, and then into water, in order to remove all bodies adhering to their surface; but several seconds always transpire between the exit of the articles from their last water bath, and their immersion into the gold-bath; this affords ample opportunity for the article to suffer alteration in the air; this alteration is indeed very feeble, but it does take place.

It follows from this that the deposite of gold does not occur, strictly speaking, on a surface of pure copper, but rather on an excessively thin pellicle of oxide. Cleaning by the moist method is, therefore, not the mode which places the surfaces in the condition most suited for the adhesion being as strong as possible; cleaning by the dry process does not present the same inconveniences, because it admits the exposure of the surfaces without fear of so immediate an alteration as occurs when they are moist. In fact, in the trial experiments lately made for gilding by immersion, the following methods of cleaning have been employed:

1st. By merely rubbing with very fine pumice stone powder and a brush, or even by scraping the surface with a sharp instrument;

2nd. Cleaning in nitric acid or in mixtures of this acid with sea-salt and soot;

3rd. Cleaning with solution of caustic soda, marking seven degrees of Baume's areometer; and in solutions marking 30 degrees;

Digitized by Google

4th. Cleaning with solutions of soda and ammonia;

5th. Cleaning with a mixture of caustic soda and sal-ammoniac;

6th. Cleaning with a mixture of concentrated acid and sea-salt.

To secure the adhesion of gold to brass plates, the following trials were made; one side of each gilded brass plate was cut, in order to facilitate the separation of the gold, in case the adherence should not have been perfect. With the same object in view, the plate was then bent in different directions, and afterwards hammered. The following conclusions were derived from these trials; conclusions which may with equal reason be applied to articles gilded electro-chemically, after the cleansings described.

With cleansings by the dry way, durability and solidity are obtained for gilding,—durability, for it is thicker; solidity, for it resists the physical trials to which it is subjected. It must indeed be observed that the appearance is not always satisfactory, especially when the surface has not a uniform character. Hence it is demonstrated that cleanings by the dry method have a great superiority over those by the moist method, but unfortunately there are many cases, and these by far the majority, in which it cannot be adopted, especially for articles of jewellery; and even when it may be made of service, the time it would require would be so heavy an expense, that it could not be introduced in the arts: cleansing by the moist method must therefore be almost always adopted, avoiding at all times the inconveniences already pointed out.

The employment of mercury removes this difficulty, besides serving as the medium between copper, and gold or silver, to determine combinations by contact; it also preserves the copper from all alteration before its immersion in the metallic bath.

M. d'Arcet, who has directed his attention with success to everything connected with the art of gilding, some time ago pointed out that, to avoid the effects of the liberation of nitrous gas, for the advantage of health, it was advisable to place the cleaned articles, which were to be gilded by mercury, in a diluted solution of protonitrate of mercury. We can indeed conceive that, by this means, it becomes more easy to apply the gold on the articles. Mr. Elkington, in his specification, has recommended the same mode in gilding by immersion, to give the *matt* after previous cleaning with acids, but he confines himself to only a single immersion and to one washing before plunging into a boiling gold bath; he can

Digitized by Google

only imperfectly amalgamate the surface of the copper, on account of the short duration of the immersion.

In order to obtain the best effects of gilding, with respect to durability and solidity, I amalgamate articles in the following manner:—When they have been simply immersed in the solution of proto-nitrate of mercury, and washed in abundance of water, they are rubbed with leather in order to spread the mercury thoroughly; and the immersions are repeated until the metal is equally diffused over the surface. If we confine ourselves to spreading lightly without rubbing, the surface remains dull; if we brush it, it acquires a brilliant appearance. If the articles, being thus prepared, are plunged into the bath of cyanuret of gold and potassium at a temperature of 25 or 30 degrees, and the simple constant battery is put into action, in less than a quarter of an hour the objects are gilded, either dead or brilliant, but with a dead surface comparable, to a certain degree, with that of clocks, which is a quality not easily obtained with the process in use. If we wish to give value to electro-chemical gilding, we must employ jointly both methods, and take mercury as a medium, but not in so great a quantity as in gilding by mercury. The temperature of the operation for bringing up the colour is sufficient to drive off the mercury, so that the advantages are united of the combination of the gold with the copper, and of an almost unlimited thickness of gold.

It is easy to explain how electro-chemical gilding on copper, when the coat is very thin, eventually alters by contact with moist air. Under such circumstances, here and there are seen little points of hydrate of copper; an effect equally evident in gilding by immersion, wherein only a thin layer of gold is deposited. If an article thus gilded, by either of the two processes, be digested in nitric acid, diluted in order to avoid a tumultuous action, the copper is dissolved by degrees, and there remains a net-work like gauze; the articles are therefore covered with a similar net-work, and, if they are left in a moist place, they must, in course of time, be attacked in the same manner as they were by the diluted nitric acid.

The effect must be even more rapid than if the copper were alone, the surface being every where covered with voltaic pairs, gold and copper, the constant action of which accelerates the oxidation of the copper. There is no need to fear the same inconvenience by following the path I have just pointed out, for the surface of the copper may be uniformly gilded, and if the coating is thick, as it may be rendered by electricity, we have every guarantee to assure the unalterability of the coated metal. It must never be lost sight of that, in the

Digitized by Google

application of gold on copper, or of one metal on another, two conditions must always be united—adhesion, and sufficient thickness of the deposited coating, that the atmospheric influences may not exercise their action on the metal, through the innumerable interstices that are left between the particles of deposited metal.

On the aspect of gilded or other surfaces.

Before the electro-chemical application of metals or of their oxides, scouring and pickling (*dérochage et décapage*, Fr.) were employed; the object of the latter operation was not only to remove all impurities, but also to give them an aspect according to the molecular state which was desired to be obtained on the surface: thus, if the *brilliant matt*, the *dull matt*, the *dull sombre*, were required, the preparation in question must vary in the different cases. Different means are known in the arts by the aid of which these preparations are made. I will offer a few considerations on the physical causes which produce the different molecular conditions, because it will then be easier to adopt the course to be pursued in order immediately to obtain the *matt*, the *polish*, &c.

The *polish* of a surface consists in the property it possesses of reflecting the light regularly on certain points, which requires that this surface be composed of particles all arranged in the same manner, that is, having their upper facets placed in the same plane. By this means, the reflection of light is regular.

The *matt*, on the contrary, appears to be the result of the irregular reflection of light,—a condition which is complied with when the surface is covered with an infinity of little asperities whose facets are determined in all sorts of directions. It follows that exterior objects are reflected by this surface, with a greater or less degree of confusion. There is entire absence of image when the particles are arranged in the most irregular manner possible.

This being understood, when a metallic surface, either polished or matted, is submitted to the uniform action of an electric current, in a suitable solution, in order to be covered with an excessively thin layer of gold, silver, or other metal, it is very evident that the primitive state of the surface will not be sensibly changed; for, in the former case,—that in which the surface is polished, all the regularly situated parts of the surface will be respectively covered with a film that, on account of its thinness, will not change the primitive molecular state; in the second case, that is with the *matt* surface, the irregularities will still preserve their same relation; for

Digitized by Google

there is no cause why this situation should be changed. It is very evident that this state of things can only subsist as long as the deposite is excessively feeble; for, if it were sufficiently abundant, it would fill the voids which separate the irregularities, and then the state of the surface would change.

Thus then, when a metallic surface of gold, silver, copper, or zinc, is prepared so as to present the polish, or the matt with all its shades, we may be assured that, on depositing on it another metal electro-chemically, in a very thin film, the molecular state of the surface will not be sensibly changed.

The considerations I have just presented will suffice to show plainly how any desired molecular condition may be immediately obtained. In fine, they may be summed up in this:—as is the surface, so is the gilding.

In another memoir, I will describe the mode of preparation which each metal should undergo, before placing another metal on its surface.—[A.]

At the subsequent meeting of the Academy, M. Becquérel communicated a short note stating that he had succeeded beyond his anticipations in depositing on gold plates, from the solution of lead, colours possessing every shade; but that they are not obtainable on oxidizable metals. He also states that it is possible to obtain *uniform* tints on gold plates "by arranging the apparatus so that the plate is parallel to the negative electrode, as well as to the diaphragm, in order that all its points may receive the same electro-chemical action."*

XX. *Some Notes on the Present State of the Study of Electricity in England, collected during a recent sojourn in that Country.* By M. le Professeur A. de la Rive. Archives de l'Electricité, No. 9, t. iii, p. 333, July 18, 1843.

(translation.)

The study of electricity is always a favourite and popular study in England. The beautiful researches of Faraday, and the important labours of Daniel, Grove, Wheatstone, and so many others, have continued to draw attention toward a

* These coloured deposites are in truth the metallo-chromes of Nobili, the translation of whose paper on the subject will be found in the first volume of Taylor's "Scientific Memoirs." For the full particulars respecting the mode adopted to obtain the colours on steel plates,—to obtain them in any variety of pattern, and to produce the chromatic scale, which is a series of plates each with a uniform and distinct tint, the reader is referred to Mr. Gassiot's paper in the 4to. vol. of the Proceedings of the Electrical Society, Dec. 17, 1839.—[Ed.]

Digitized by Google

science which the genius of Davy and the admirable sagacity of Wollaston had already so highly elevated. At the present moment Faraday is delivering in London *Lectures on Electricity*, at The Royal Institution, whither resort in crowds not only men of the world and elegant ladies, who come in great numbers to admire the grace and enjoy the charm which the amiable Professor so well knows how to diffuse over his teaching, but also the *savants*, who always find something new to acquire from the interesting views of the learned philosopher.

Faraday carefully laid down, in his lessons, his recent researches on the induction of static electricity,—researches which tend to effectuate a great change in the study of the electric phenomena of tension. He was equally industrious in renouncing all electric actions at a distance, and explaining them by a communication of electrical effects brought about by means of the molecules of the medium interposed between the two bodies which, in the old theory, are supposed to act at a distance on each other. This mode of viewing it appears to be adopted by philosophers, and is carefully unfolded in a treatise on chemistry, recently published by Prof. Daniell. Among the beautiful experiments made by Faraday, in his course, we may mention those relating to the tendency of electricity to arrange itself on the surfaces of bodies; the talented English professor shewed that, even with mere open metallic gauze, this tendency is such that no trace * of electricity is found on the interior surface of a cylindrical envelope made with this gauze, while the exterior surface is electrized.

Mr. Faraday has just terminated a beautiful series of researches on the electricity developed by steam; he has succeeded, as indeed he always does, when he undertakes a subject, in clearing up and advancing this point of electrical science. He shews that the abundant production of electricity, which accompanies the liberation of condensed vapour, is an effect of friction; † we shall publish entire in our next number, the memoir which contains the details of the researches of the English philosopher on this subject.‡ Mr. Faraday, with his usual good nature, was kind enough to show me the greater portion of the experiments described in his memoir,—experiments which are especially delicate when the weather is damp, and which, thanks to the dexterity of the experimenter, succeeded perfectly well when I witnessed them.

I regret also being compelled to defer to our next number the publication of a recent work by Professor Daniell, on

* Vide Elec. Mag., p. 71 and 72. † Vide Elec. Mag., p. 60.

‡ See a subsequent page of the present number.

Digitized by Google

Voltaic Combinations, in which, among other interesting points, the author shows that Ohm's law which, in valuing the effects of the current, estimates the resistance of all the parts of the circuit, may be equally well applied to the chemical theory of voltaic electricity, as to the contact theory. Mr. Daniell now employs with advantage, in his constant battery, diaphragms of porous earth; it is only necessary that they be of very porous earth. By thus replacing the diaphragms of wood or membrane, Mr. Daniell will have rendered his battery much more convenient in use; this is one service more which he will have conferred on electricians, who will always remember with gratitude that it is he who first realised the idea of procuring for them a constant battery.

Mr. Wheatstone, the colleague of Mr. Daniell at *King's College*, of which he is also a professor, is always engaged in electricity with his well known activity and sagacity. It is only a pity that so many beautiful researches, of which several are terminated, receive so rare and so incomplete a publication. In endeavouring to raise the veil which conceals them from the knowledge of all those whom they may interest, we will not pass the limits of the discretion imposed upon us by the open and confident manner with which the author kindly communicates his labours to those occupied on the same subject as himself.

It is well known how Mr. Wheatstone has turned to account the property possessed by a piece of soft iron of immediately acquiring and losing magnetic properties, by the establishment or the interruption of a current in a wire covered with silk, with which it is surrounded. He has applied this principle to the construction of his improved telegraph; it is sufficient now to have two conducting wires between one station and another, to be able to transmit all the letters of the alphabet and the figures, which may be required in a telegraphic communication. By means of a commutator, which serves to interrupt or to establish the circuit at one of the stations, soft iron is magnetized and demagnetized an equal number of times at the other station. The commutator is a wheel turning on its axis, and the circumference of which presents 48 portions alternately conductors; so that, for one complete revolution of the wheel, the current is 24 times interrupted and re-established; a letter of the alphabet corresponds to each of these 24 alternations; the soft iron at the other station is in like manner magnetized and de-magnetized 24 times. This alternate state of the magnetization and non-magnetization of the soft iron permits of an oscillating motion being given to a small appendix, also of soft iron, which re-

Digitized by Google

sults from the alternate attraction and non-attraction exercised on it by the electro-magnet; and this alternate movement, which is communicated to a wheel, successively brings before the observer each of the 24 letters of the alphabet, which are engraved on this wheel. Care must be exercised that there is agreement between the letters corresponding to the alternations of the commutator, and those produced by the alternate movement produced by the magnetization and the de-magnetization of the electro-magnet. I have seen this telegraph in action; it works with very great ease and facility. Suppose, for example, the commutator placed at A, and the letter A brought to the observer by the electro-magnet; (at each station they agree to arrange the apparatus so that the starting point is the same.) We wish to transmit the letter D: the commutator must be moved onward three alternations; B, C, and D, have been successively introduced at the other station; then we stop, and D remains fixed for an instant at the other station; and so on for each of the other letters. A large bell which is struck by a piece of soft iron, that is attracted by the electro-magnet at the moment when the circuit is established, serves to give the signal. It is evident that, in order that the transmission be reciprocal, there must be a double set of apparatus, so that each station may possess those necessary to transmit, and also those necessary to receive the communication. I have been induced to give the description of Wheatstone's beautiful apparatus; imperfect as it is, this description may nevertheless render comprehensive the principle of the electric telegraph, such as its inventor constructs it at the present moment.

Mr. Wheatstone has moreover applied the same principle to the transmission of motion to the hands of a clock, and to other hands arranged on a dial, in the same manner as those which are moved directly by the clock; and they progress at precisely the same rate, which enables us to employ only a single clock-movement to make many pairs of hands journey round their respective dials, at places widely distant and apart.

But the last and most important, or at least the most ingenious of the applications of the principle, which the talented English philosopher has made, is in respect to the use he has derived from it to register meteorological observations. The motion of the barometer and thermometer, &c., may thus be estimated every half hour. The apparatus for producing these results is very complicated, but very perfect. A mechanical motion is given to many parts of the apparatus; then the contact of the mercury with a fine platinum wire placed in the tube of the meteorological instruments, closes

Digitized by Google

the circuit and determines certain mechanical effects, by means of the magnetization of the soft iron. The desired result is obtained by the combination of these effects with those resulting from the movement constantly impressed on the different parts of the apparatus, by a mechanical force, such as clock motion.

I pass over in silence several other ingenious apparatus, constructed by Mr. Wheatstone, and to which he has applied the same principle. He has, like many other philosophers, endeavoured to apply it to the production of a useful mechanical force; but he does not seem to me to have completely succeeded on this point; and I am convinced that a long period must yet elapse, before steam is, in this respect, dethroned by electricity.

Mr. Wheatstone is also employed on a very important point in electricity, that is to say, the measure of the electromotive force of a pair, and of a series of pairs forming a battery; as well as that of pairs of different kinds. His methods are very ingenious and very delicate; they are founded on a very accurate method of measuring the relative lengths of wire necessary to be introduced in the circuit, so as to furnish means, by augmenting or diminishing the resistance, of giving to the current the same definite intensity. I witnessed a great many experiments made by Mr. Wheatstone, and was struck with the vigorous, I might almost say, the mathematical exactness of the results which he obtains. It is to be hoped that the talented English philosopher will not delay publishing his researches on this subject; their publication will afford very great interest to all those occupied in electricity. One thing I remarked in Mr. Wheatstone's experiments, and there is, I think, no indiscretion in divulging it, as it is already known, if I mistake not,—it is the constancy of the pair formed with amalgam of zinc, in a tolerable state of fluidity, placed in a porous tube, the porous tube itself being placed in a vessel containing solution of sulphate of copper and the plate of copper, which is the other metal of the pair. Although there is but one liquid between the two metals of the pair (sulphate of copper) the effect is perfectly constant for several hours. A pile may be constructed of several pairs of the same kind, and its effect is also remarkably constant. Mr. Wheatstone has substituted other amalgams for the amalgam of zinc, in particular that of potassium, in the use of which many very curious phenomena are presented, and also a great voltaic power.

I had the pleasure of seeing in action Mr. Grove's *Gaseous*

Digitized by Google

*Battery;** this battery can decompose water with seven or eight pairs. If the number of pairs is greater, the decomposition is more rapid. This pile appears to me to present one of the most curious cases of voltaic action. In fact, this is what occurs in each pair of the circuit. Acidulated water, and consequently a conductor, is terminated on one side by oxygen, and on the other by hydrogen gas; these two gases are not in immediate contact, for they are separated by a column of water. However, if they are united by a plate of platinum, instead of combining together, as they would do if they were in contact, but which is impossible here, the oxygen combines with the hydrogen of the water, and the hydrogen with the oxygen of the same water. This water, therefore, is in the same condition as when it conducted the voltaic current: its molecules mutually exchange their oxygen and hydrogen, so that the hydrogen of the last molecule, being free, combines under the influence of the platinum, with the gaseous oxygen; and the oxygen of the other extreme molecule combines in the same manner with the gaseous hydrogen. It must not be forgotten that the platinum plate, which is in the gaseous element, is at the same time plunged in water, a necessary condition to the success of the experiment, and the establishment of the current. To assure the success of the experiment, a tolerably extensive surface must be given to the platinum plates, and it must be covered with pulverulent platinum, which is termed *platinizing* the surface.

Mr. Grove has just communicated to the Royal Society of London, some new researches on his Gaseous Pile; he has studied respectively the effect of different gases, and has succeeded in fathoming many delicate points relating to the species of action which occurs in this pile. As soon as this new work shall have been made public, we will hasten to communicate it to our readers.

Mr. Gassiot, whose name is well known by all who have watched the progress of the discoveries made in electricity during the last few years, whilst I was in London, invited a party to view some beautiful experiments made by means of voltaic batteries of great power. I had the pleasure of assisting at these experiments, or rather at this interesting *electrical soirée*, as it was called by the amiable *savant*, who had been so kind as to open his house, with the most cordial hospitality, to the numerous assistants who crowded forward to see and to admire. A Grove's battery of 100 pairs (each presenting a surface of about 16 sq. in.) produced magnificent effects; the luminous arc, between the charcoal points, lighted up a very

* Vide Elec. Mag. p. 58.

Digitized by Google

large apartment, and made all the wax lights become pale, for their light almost entirely disappeared before that of the electric current; wires, nearly a line in diameter, were made red hot to the length of more than a foot. I saw the curious experiment,* made for the first time by Mr. Gassiot himself, and which consists in touching, so that they cross at the point of contact, the two wires connected with either pole of the battery; the part of the wire, comprised between the point where they touch and the poles, becomes incandescent, which is not surprising; the part of the same wires, which is prolonged beyond their point of contact, in like manner, becomes hot, which may be explained by the conductibility of these metals for caloric,—caloric, the source of which is in this case at the point of contact. But the most surprising circumstance is that the prolongations of the two wires, though of the same length and diameter, become very unequally heated; the part of the wire, which is the prolongation of that connected with the positive pole, becomes so incandescent that at last it melts; the other, which is the prolongation of the negative wire, also becomes hot, but much less so. To what is this difference due? It is difficult to say without having studied more deeply this curious phenomenon. In the experiment which I saw, copper wires were employed: I am not aware whether it succeeds with other wires, such as platinum.†

Among the other brilliant experiments that I witnessed, I will in addition relate the following, which seemed remarkable. The two ends of the copper wires, connected with each pole of the battery, were placed on a piece of sulphuret of antimony; the sulphuret in a solid state not being a conductor, the current cannot be transmitted: the two ends of the copper wires are made to touch; a considerable amount of heat is developed at the point of contact, which melts the sulphuret; in this state of igneous fusion, the sulphuret becomes a conductor; the ends of the copper may now be moved apart so that there shall be between them melted sulphuret, without the current ceasing to pass. The high temperature increases the melted portion of the sulphuret; the metallic points may be still further separated; by this means there is at last obtained, between these two points, a stream of melted sulphuret of antimony three or four or even more inches in length. I also saw at Mr. Gassiot's, a water battery of 3,600 pairs; these pairs are each formed of a cell of copper, containing a cylinder of zinc soldered to the copper of the following cell; each pair is placed in a glass

* Vide Trans. Elec. Soc. p. 65, Oct. 16, 1838.—Ed.

† It does succeed with platinum and other wire.—Ed.

Digitized by Google

vessel, filled with rain water. The pairs are insulated from each other with much care, by means of glass supports and glass cells, covered with gum-lac; in short, every precaution is taken to ensure perfect insulation. Such a pile as this exhibits very strong tension at each of its poles; it charges Leyden jars, and sparks may be drawn from it like those obtained from an electrical machine.

I must here terminate this short review; I might have dwelt on a host of other interesting labours effected in England, either by the electricians of whom I have spoken, or by those whom I have not had occasion to mention. But I will supply these omissions by giving ere long the researches, which I cannot at the present moment present to my readers.

[A.]

XXI. *Researches on the Generality of Magnetism, or Supplement to the Experiments of Coulomb on the same subject.* By Dr. DE HALDAT. Comptes Rendus, 1841;—Mem. de l'Acad. de Nancy, 1841, (From Arch. de l'Elect. No. 3, p. 285.) 18 July, 1843.

(TRANSLATION.)

THE author who has subjected to examination a great number of substances, both mineral and organic, did not confine himself to causing the oscillations of small needles of these various substances, as had formerly been done; he gave them a greater dimension, and had recourse to the force of torsion, not to measure the magnetic force acquired by these needles under the influence of powerful magnets, between which they were placed, but to place the existence of this force beyond all manner of doubt. The metals furnished him with the most evident proofs, and, as he expected, on account of their density being greater than that of organic substances.

Needles formed of different substances, in which iron is not present, act essentially as iron or steel needles placed in the same circumstances, subject to the same influences. They oscillate on being removed from the direction of the common axis of the two magnets, and replace themselves and maintain themselves there, when the torsion of the film of silk, by which they are suspended, is not strong enough to retain them from it; they place themselves in a direction oblique to this axis to restore the force to equilibrium, when it has power

Digitized by Google

to retain them; and finally they present the phenomena of a weakened needle, when the two magnets correspond by poles of the same name.

To reply to the objections drawn from the supposed presence of iron in the needles which present the well known magnetic phenomena, M. de Haldat undertakes to prove by direct analysis of these substances;—1st, that there are some which do not contain an atom of iron; 2nd, that extremely small quantities of this metal do not in the least increase the disposition to acquire the magnetic state, in substances which do not contain it naturally; and that, when the quantity of iron which they contain has power to give them the magnetic force, this substance becomes appreciable by chemical agents; 3rd, that iron, in a state of combination, does not give to the bodies which contain it, the disposition to acquire the magnetic state.

From all the facts collected in this memoir it is concluded that the magnetic fluid or agent exercises its influence on all bodies, but in degrees which are very various and so different that, whilst some manifest their power under every circumstance and without any extraneous influence, there are others in which it does not become apparent except when they are subjected to the influence of bodies which enjoy it in the most eminent degree.—[A.]

XXII. *On the Electric Current developed by the Action of Gaseous Bodies on Platinum.* By M. Ch. Matteucci. From "Les Comptes Rendus," April 17, 1843., No. 16, p. 846.

(TRANSLATION.)

At the sitting of October 22nd, 1828, I communicated to the Academy a note relative to the electric current, developed by two platinum plates, on their being plunged together in a liquid, after having been for a time, the one in hydrogen, the other in oxygen gas. This experiment was supplementary to those of M. Becquérel, by which he explained, in a very satisfactory manner, *secondary polarities*. I have just read, in the English Journals, that Mr. Grove has conceived the happy idea of uniting into piles, several elements, each of which is formed of one plate of platinum plunged partly into hydrogen gas, and another plunged in like manner into oxygen. This

Digitized by Google

application, and the different researches of M. Schoenbein on the same subject, induce me to publish some experiments I formerly made, and which I have lately continued.

These experiments may be easily made in the following manner:—I take a glass tube, open at both ends, a decimètre (4 in.) long, and 2 or 3 centimètres (1 in.) in diameter. I introduce into the interior of this tube a platinum plate, fixed in a cork, which exactly closes one end of the tube. A copper wire is soldered to the plate. This plate, before being introduced into the tube, is dipped two or three times into a concentrated solution of chloride of platinum, and alternately heated to redness in the flame of a spirit lamp. By this means, the plate is uniformly covered with a layer of finely divided platinum. With two tubes thus prepared, and a very sensible galvanometer, having a long coil of wire, all the experiments I am about to describe may be made. I begin by filling the two tubes with distilled water that has been boiled for some time, and immediately inverting them in a vessel filled with the same liquid. The circuit is then completed with the two wires, which are soldered to the plates, and with the galvanometer. It is well to have a break in the circuit, which is obtained by means of a capsule, filled with mercury, into which is placed one wire of the galvanometer, and one of the wires of the plates, when the circuit is to be completed. The plates which I employed were 4 centimètres long, and one wide. When the circuit is completed, in the manner I have mentioned, there is generally no deviation; if deviation does occur, the circuit must be kept closed till it has disappeared; then, on opening, and afterwards closing the circuit, the needle will be sure to rest at zero.

On employing water acidulated with sulphuric acid, instead of distilled water, the needle is not easily brought to rest at zero, and the results are rarely constant. Let some hydrogen gas be now introduced into one of the tubes, so that two-thirds of the platinum plate are in contact with the gas. On then closing the circuit, a deviation occurs, which in my instrument amounts to 15 or 20 degrees, and even more; the direction of the current in the liquid is from the plate which is in contact with the gas, to the other, which is entirely in the liquid. Instead of introducing hydrogen gas, I introduced oxygen; it is needless to say we must always be sure that the needle remains at zero, when both tubes are entirely filled with liquid. On closing the circuit when one of the plates is in contact with oxygen gas, a deviation of only 5 or 6 degrees is obtained, but it is equally constant with the greater deviation obtained with hydrogen. The direction of the current is

Digitized by Google

from the plate, which is entirely immersed in water, toward that which is in contact with the oxygen; thus has this current a contrary direction to that of the current obtained with hydrogen. I tried the experiment by introducing atmospheric air into one of the tubes; I never obtained any sensible motion of the needle. This result, which we will explain in the sequel, is deserving of notice, because it points out to us that the currents obtained with the other gases, are not due to the inequalities of the surfaces of the two plates which are immersed in the liquid. I tried the experiment by introducing nitrogen into one of the tubes: I obtained a deviation of 8 or 10 degrees; the direction of the current in the liquid was from the plate contained in the nitrogen, toward that entirely immersed in the liquid. Since the currents developed by oxygen and nitrogen are opposed, it is natural to explain from that why there is no current with atmospheric air. I introduced carbonic oxide into one of the tubes; this gas acts like hydrogen, and with very nearly the same intensity. On the contrary, carburetted hydrogen acts like oxygen, but much more feebly. A mixture of hydrogen and oxygen, in the proportions of water, acts like hydrogen, but rather more feebly. A mixture of the same two gases, in the proportions of 9 oxygen, and 1 hydrogen, still gives a very sensible current, always in the same direction as hydrogen. In all these experiments, the volume of the gas diminishes more or less rapidly; with the explosive mixture, however, the diminution is most rapid. In order to obtain constant results, every time an experiment is tried with a new gas, the plates must be taken out to be heated to redness in the flame of the spirit lamp.

Whatever gases may be made use of in the experiment, it is observed that the current does not attain its maximum intensity until after a certain time. I will quote one experiment which will render this very evident. After having introduced hydrogen into one of the tubes, I closed the circuit, and obtained 12°; I immediately opened the circuit, to close it again after a lapse of 4 minutes, when I obtained 23°. Renewing the same experiment, and always leaving the circuit open for the same period, I obtained in succession 28°, 32°, 35°, 43°, 51°, 62°. When the plate has been for some time in contact with the gas, the current continues, even after having taken away the gas and filled the tube with liquid.

The influence of cold over these phenomena is worthy of notice. While I was obtaining 60°, in an experiment made with hydrogen, I touched the tube containing the gas for several seconds, with a piece of ice. Then, on closing the

Digitized by Google

circuit, the deviation only attained 25°; and it was not till after some time that I again obtained 60°. The time necessary to make the influence of cold disappear becomes very short; the flame of a spirit lamp may be brought near the tube for an instant. I confirmed this result by many experiments. In order that the influence of time may be exercised, the plate must be made cold while in contact with the gas. I shall not relate the results obtained when using gases very soluble in water; these results are far from being constant; and it was only with carbonic acid that I always obtained the current in the same direction as that given by oxygen and by carburetted hydrogen.

The following results were obtained by introducing two different gases into the two tubes; these results may, in some sort, be anticipated from those obtained with a single gas. Thus, hydrogen and oxygen, separately introduced into the two tubes, nitrogen and oxygen, hydrogen and carburetted hydrogen, hydrogen and nitrogen, carbonic oxide and oxygen, give a current, the direction of which is, in each case, from the former gas to the latter in the liquid, and which is more powerful than that given by each of the gases separately. M. Becquérel, in the chapter of his work where he relates my first experiment, has established the action of nitrogen, in respect to hydrogen and oxygen, precisely as I have just given it. It is worthy of notice that nitrogen, which gives the current in the same direction as hydrogen and the explosive mixture, when they are mixed in small proportion with these two latter gases, [obscure in the original] sensibly weaken the current they develope. I have only to mention in addition, the experiments I have tried by uniting into a pile several elements, each of which is formed of the two tubes previously described. I united into a pile six pairs of tubes; the two tubes of each pair contained, one hydrogen gas, the other oxygen. The entire pile gave me a current of 19°, the direction of which, as usual, was from the hydrogen to the oxygen in the pile. The following deviations were given by each of the pairs employed separately: 23°, 14°, 17°, 12°, 20°, 27°. A pile of five elements, each pair of which was formed of one tube, entirely filled with water, and of another into which I had introduced nitric oxide, gave me 11°. These results do not appear to accord with those given by Mr. Grove. It is however right to mention that this clever philosopher experimented with fifty elements, employing acidulated, instead of distilled water.

The first time I observed the phenomena I have just described, I advanced the hypothesis that the electric current

Digitized by Google

was due to the combination of the two gases, oxygen and hydrogen, effected by the intervention of the platinum. It is impossible for me, after the results contained in this memoir, to admit that explanation; in fact, we have seen that each gas acts separately, and that the current is developed by the action of one gas on platinum in the presence of water. Admitting, as it seems natural to do, that the part of the liquid is only that of a conducting body necessary to complete the circuit, there remains, in explanation of the phenomena, the action of the gas, whatever it may be, on the platinum. This action would charge the platinum with negative electricity, and the hydrogen gas, or those which act like it, with positive electricity, which would be diffused in the liquid. When the two gases, oxygen and hydrogen, are mixed, and are in the presence of platinum, the current obtained would be merely due to the difference of the effects, which each gas produced separately. In all cases the two gases would become charged with contrary electricity, and consequently would be in a condition to combine more readily together. The formation of water by platinum might thus be explained; but the developments of electricity, by the action of different gases on platinum, remains to be explained. It is a field open to new researches.—[A.]

XXIII. Notice of Mr. Bain's *Voltaic Governor*. By the Editor.

Our attention was first directed to this instrument by a letter from its inventor, inserted in *The Mechanics' Magazine*, No. 1043; and we have since that seen it in action at Mr. Knight's.

It has evidently been designated a voltaic *governor* from its power of controlling the electric force, as the governor of an engine controls the force of the steam. In all forms of the constant battery, it is well known that the energy of the action declines in proportion as it is continued; and that though, for many practical purposes, the action may be assumed "constant," and employed as such, yet it is in truth a vanishing or decaying action, which requires continued revival for continued operations. The invention of a battery, having the power of producing a comparatively constant action for a lengthened period of time, is beyond dispute to be ascribed to Prof. Daniell: his means of obtaining this are by surcharging the exciting liquid with sulphate of the oxide of

Digitized by Google

copper, so that the exhaustion, consequent on continued action, may be recruited as it occurs. The various means of adjusting the action of this, and indeed of all varieties of the more or less constant arrangements, to the work to be done, are familiar enough to electricians,—being merely the taking advantage of the modifications of a *chemical* character, of which the various elements are susceptible. The novelty here introduced by Mr. Bain is the employment of *mechanical* power in conjunction with chemical affinities,—causing the two forces to counterbalance each other and produce an equilibrium or given constant action.

We are indebted to the editor of *The Mechanics' Magazine* for the following diagrams of two different instruments, each of which Mr. Bain has found effective.

In Fig. 1, A A is a wooden stand and framework, supporting the clock mechanism E E, and containing (in this case) two cells, B B of a Smee's battery; C C are the zinc and the platinized plates, fixed in the wooden bar, D D, and in proper electric connection: M N are binding-screws attached to the respective metals of the battery. By the attached wires the electric current passes round the electro-magnet, F. G is the keeper of the electro-magnet. It is obvious that a given intensity of electric action will always produce in the magnet a magnetic power to attract the keeper from a given distance: and, conversely, the distance between the keeper and the magnet being given, the same amount of electric action must be exercised on the soft iron core, when the keeper is attracted from the said given distance. The instrument then is used in the following manner:—By means of a thumb-screw, the electro-magnet is moved till the index, appended to it, points to any given degree of the scale I; the frame D D, with its attached plates, is liberated, and allowed to sink into the acid solution, contained in the cells. Now, this frame is suspended to the clock mechanism, acting as the weight or motive power; and its freedom to descend lasts only as long as the wheels are free to move. As the plates become gradually immersed in the acidulated solution, the energy of the current increases; and when it reaches the given standard, marked by the index, the keeper G is attracted to the magnet. But the arbor of the keeper carries a pin K, which, by the backward motion of the keeper, comes into contact with the pin L, projecting from one of the wheels, and thus stops the motion and, with it, the further descent of the plates. When the action on the plates, and the reduction of the strength of the solution shall have diminished the electro-motive power of the system, the keeper

Digitized by Google

Fig. 1.

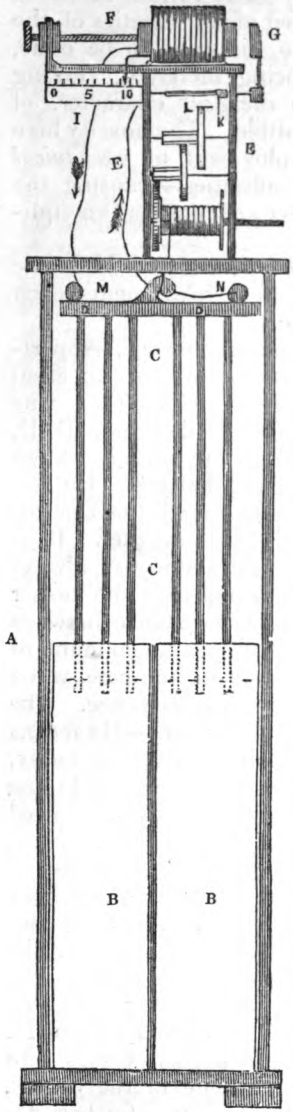
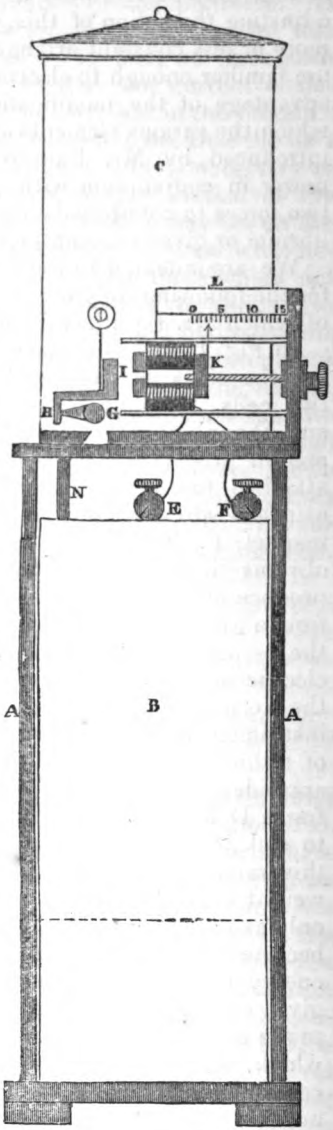


Fig. 2.



is again liberated from the magnet, and, by the force of a small spring, it returns to its original position. The plates now continue their descent till the action is again exalted to

Digitized by Google

the given standard, when the keeper returns to the magnet, and the descent is a second time stopped. "And," as Mr. Bain says, "so it will go on, keeping the electric current within one degree of the necessary strength, until the whole metallic surface comes into contact with the liquid."

Fig. 2 is another arrangement of the "voltaic governor." B is a cell of a Daniell's battery, placed within the frame A: it consists of an outer cylinder of zinc to which are attached several shelves, supporting muriate of ammonia,—the shelves extend above each other, from the top to the bottom of the cylinder; and of a porous cylinder containing a rod of copper, on which slide several copper discs, each furnished with projecting pins pointing upwards, so that the discs are kept, above each other, at a proper distance apart. The copper is connected with the binding screw E, the zinc with the screw F; and these screws are respectively connected with the electro-magnet, K. On commencing operations, water is poured into the battery, as high as the level of the first copper disc; the copper rod, having one disc attached to its lower end, is placed in the porous cell; powdered sulphate of the oxide of copper is placed on the disc to the level of the pins; another disc is now slid on, and sulphate placed on it; and so on, till the discs are all on the rod. The water, for exciting the battery, is contained in the cistern C; from which, on opening a stop-cock, it flows by the pipe G. The distance between the keeper, I, and the electro-magnet, K, being adjusted as with the former instrument, the stop-cock is opened and the water continues to flow into the battery by the pipe G, until the intensity of the magnetic action is such as to attract the keeper, when the pipe G is closed by the stopper H, and the flow of liquid ceases, to be again renewed, as before, when the action is reduced. In this last instrument, there seems not any provision made for conveying water to the zinc; and this is very essential.

We are not in possession of any data illustrative of its action; but it would appear far less efficient than the other, because the maximum action is not obtained by the mere *contact* of water with the metallic salts, but by its becoming *saturated* with them; so that the action would become much exalted *after* the keeper was in contact. It is evident that the current from these arrangements is employed by introducing apparatus in the circuit of one or other of the connecting wires.

There is a great deal of ingenuity displayed in the structure of these instruments, and especially in the former, which would seem to bring us *very closely toward*, but not *actually*

Digitized by Google

to the attainment of long-continued, "constant" currents. The electrician will not be slow in perceiving that, from the time the keeper is attracted, to the time it is liberated, the action is *gradually* reducing; and that it ranges between the power which will produce attraction to the keeper from the *given distance*, and that which will attract the keeper when in *actual contact*. With this limitation, the currents may be regarded as constant; but it would be well for the inventor to examine the effects of their gradual reduction, and give the extent of the variation that occurs in the apparatus, which may be included in the circuit. C. V. W.

XXV. *Mr. Bain's Improved Pendulum.* By JOHN FINLAISON, Esq. From Account of some Remarkable Applications of the Electric Fluid, &c. p. 35.

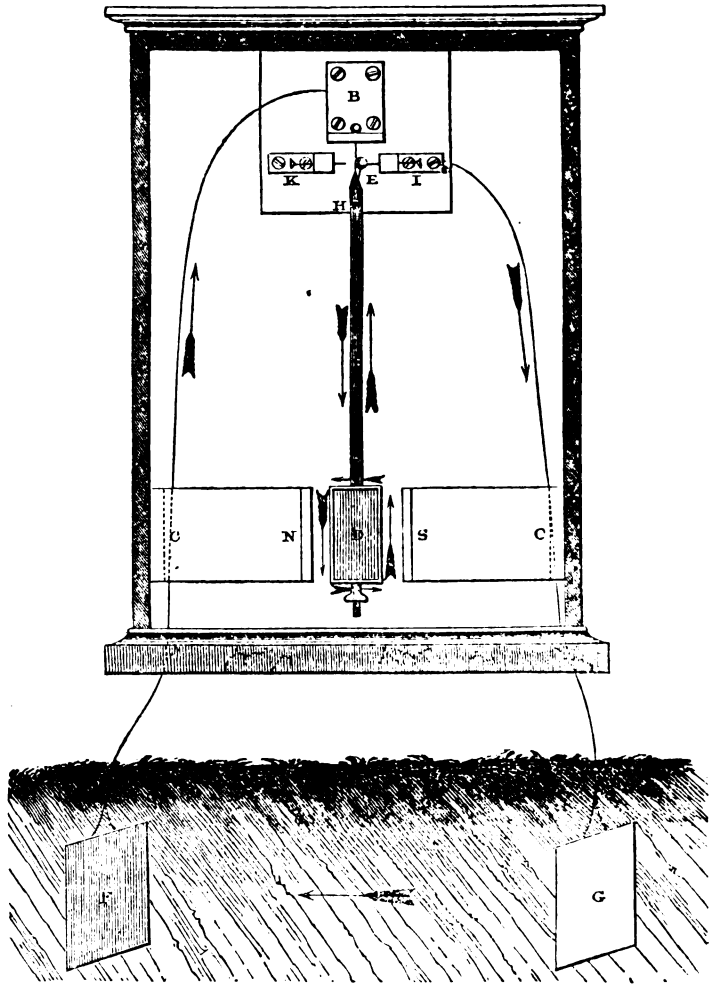
(EXTRACT.)

"THE following diagram exhibits Mr. Bain's latest improved pendulum, which is moved by a metallic surface in the moist earth of no more than four or five feet.... Can any man now foresee the important ends to which this little instrument may hereafter be applied? In the ordinary use of it for the measurement of time, diminished friction, and hence, far greater accuracy, is [are] obviously secured. Its permanence of action is probably the nearest approach yet made to the impossible chimera called the perpetual motion. Mr. Bain intends to apply it also to telegraphic purposes, in which its agency secures him improvements of the last importance, for he can certainly, by its means, discard wheels of any and every description, as well as electro-magnets. A A is a mahogany case, with a glass front; B, is a metal bracket fixed to the back of the case, and to which the pendulum, D, is suspended. C, C, are permanent steel magnets, fixed to the sides of the case in such a manner, as that the pendulum ball, D, can vibrate freely between the poles of each magnet. The magnets are so placed as that poles of dissimilar names face each other. E is a small platinum ball, affixed to a brass stem, free to move to one side or the other, being fastened to a light spindle, carried by the pendulum-rod at H. The plate of copper, F, is deposited in the moist earth, from which a wire leads to the bracket, B. The plate of zinc, G, is likewise deposited in the earth, and its wire leads to the piece of metal, I. To the lower end of the suspension spring of the

Digitized by Google

pendulum, is attached a wire, coated with silk. It is led down the back of the rod (which is wood), and then coiled

Fig. 1.



longitudinally, in many convolutions, around the edge of the pendulum-ball, in a groove previously made for the purpose. It is then taken up the back of the rod and terminates in the bearings of the spindle, at H. The action of the engine is as follows:—A constant and uniform current of electricity would

Digitized by Google

be established, and would pass through the earth, the plates and wires, in the direction of the arrows, as long as the platinum ball, E, rests on the platinum pin, projecting from the metal, I. But if the pendulum is put in motion, suppose that, at first, it were drawn outside until the ball, D, should be between the poles of the right-hand magnet, the point, H, being now farther to the right than the ball, E, the latter would fall to the left, and rest on the pin, K, until the pendulum took its vibration to the left, when the ball, E, would fall to the right, and so on continually, the action being produced by the change of the centre of gravitation at each vibration of the pendulum. This action of the ball, E, lets on and cuts off the flow of electricity at or near the extreme ends of the pendulum's vibrations; so that the convolving wire of the pendulum ball is attracted and repelled by the magnets at the proper points of its vibrations, and thus a continual motion is kept up for an indefinite period of time."

XXV. *Voltaic Phenomena; Action at the Anode; Analysis of Heating Effects; Ignition at the Surface of an Electrolyte.* By W. R. Grove, Esq. M.A., F.R.S., Prof. of Exp. Phil. London Inst.

To the Editor of the Electrical Magazine.

Dear Sir;—On referring recently to my note books of experiments, I found several facts which I had inserted for the purpose of working out when opportunity might favor me. As months, and even years have elapsed, without affording me such opportunity, and as these collateral facts rather seem to increase than diminish in number, I think they may possibly be useful to others, either as falling in with their lines of research, or as suggesting new points for experiment. Should you have a spare page in the "Electrical Magazine," you will perhaps have the kindness to insert one or two of these, which are merely given as suggestive hints, and not as having any pretension to the character of a scientific memoir.

In the "Philosophical Magazine," for Oct. 1839, I have noticed the fact that when copper formed the anode of a voltaic pile in nitro-sulphuric acid, it became inactive, and was neither oxidated, nor was oxygen evolved from its surface; differing in the latter respect from inactive iron, it perfectly arrested electrolytic action, and consequently the passage of the voltaic current. Some facts which I subsequently observed, will

Digitized by Google

throw some light on this anomaly, and, as far as I am aware, are in themselves new.

If a copper wire form the anode of a voltaic battery of moderate power in dilute sulphuric acid, it is, as is well known, gradually oxidated and dissolved. If the intensity of the battery be increased, I have found that, at a certain point, (varying with the voltaic combination employed), the action is arrested, the copper is no longer dissolved, and a galvanometer interposed in the circuit gives little or no indication of a current. Let the intensity be now further increased, by gradually adding to the voltaic series, and a very curious phenomenon is exhibited;—the copper is apparently disintegrated, boiling off, as it were, in a very fine reddish-brown powder; the heat is intense, and the electrode rapidly worn away; the powder thus formed is partially dissolved, provided the acid be not already saturated; after saturation, it subsides, and may be collected and examined; it proved to be the second oxide, or copper 32+oxygen 8, called by some authors the protoxide, by others the deutoxide. Besides employing the usual chemical tests, I analysed it voltaically, by comparing the weights lost from the anode, with the hydrogen evolved at the cathode; the following are three experiments taken from my note book, dated April 27th, 1841.—

Thermometer 60 Fahrenheit.

Exp. 1.—For	6	cub. in. of hydr.	collected, anode lost	4·2
	2	do.	do.	4·2
	3	do.	do.	4·3
				3)12·7
				4·23

Now 47·2 : 32 :: 6 : 4·07

This result was obtained with a common pair of scales, and although too coarse for a very accurate determination of the equivalent, was quite sufficient to prove that it was the full oxide; which was all I required.

The battery employed varied from 1 to 20 cells of the nitric acid combination. I generally found that the intensity at which the current was arrested was when from 5 to 10 cells were employed,—12 to 16 seldom failed to give the disintegrating effect.

The points worthy of notice in this experiment, are—

1st,—The purely mechanical effect of the voltaic current, the oxide being forcibly detached without any further chemical combination.

2nd,—The neutral point when the current is arrested, the

Digitized by Google

intensity being too great for the usual action of solution, and too feeble for the disintegrating action.

3rd,—The intense heat generated, which here, as in all other voltaic experiments appears to be proportionate to the resistance.

The experiment appears to me to be worth extension; and it will give me great pleasure to see it taken up by competent hands.

Entertaining a strong opinion that electricity is *not* a specific fluid, or fluids, but an affection of matter, (possibly a mode of motion); and believing that all electrical phenomena are intermolecular changes of the bodies, through which what is called the current of electricity passes; the following *Quere* occurred to me in some experiments on the calorific effects of voltaic electricity. If the ignition of a thin wire be the result of a change in the arrangement of its own particles, caused by an antagonist force to that which determines its aggregation, what will be the effect of this force, pushed to the extreme?—*e. g.* Voltaically ignite a given wire to fusion, arrange it so that, after fusion, the wire shall retain its position in the voltaic circuit, and what will be the result? The experiment was tried with platinum and lead wires, placed in a little gutter of unglazed porcelain, which would retain the metal after fusion. The effect upon the platinum wire was as follows:—after fusion the wire appeared to swell slightly, and then burst asunder with a snapping noise; one of the frustra again ignited, again burst, and so on, until the portions became too thick to be fused by the voltaic force employed. The broken ends presented no very remarkable appearance. My deduction from this experiment was, that the voltaic current tended to expand the wire in the transverse, and to contract it in the longitudinal direction.

With wires of lead the effects were more remarkable. After fusion, this metal evinced a tendency to contract in length; and, the direction of this contraction being followed by gently approaching the terminal wires, which touched its extremities, it appeared, as it were, to germinate; it shot out an irregular series of nodules. I may rudely compare the effect to a membranous gullet, tied with a series of ligatures, and then distended to the utmost. Each nodule pressed upon its neighbour and formed dividing facets, which, when cold, could be easily separated by the nail or by a blunt penknife.

The experiment, when carried on for some time, generally ended either in the breaking asunder of the lead, (though,

Digitized by Google

from its want of elasticity, unattended with the snapping noise,) or else the circuit was interrupted by the oxidation of the lead. I should have repeated the experiment in vacuo or hydrogen, but a specific apparatus was requisite; and this would have broken in upon some other lines of research. For the same reason, I did not repeat the experiment with wires of other metals.

The above experiment shows, I think, a distinct transverse force exerted by the voltaic current upon solid conductors. This force, its magnetic and other physical relations, promises an interesting field of experiment.

Another effect I have observed in the course of some experiments on the voltaic arc:—In examining the arc when taken between terminals of zinc, in an atmosphere of nitrogen over water, I observed a remarkable and rapid increase of the gas, and found it due to an accession of hydrogen: the effect continued long after the evaporation of the small quantity of water, with which the zinc terminals were wetted in passing up through the pneumatic trough. On repeating the experiment over mercury no such effect was perceptible. The hydrogen appears, therefore, to have been eliminated by the decomposition of aqueous vapour; but the striking fact in the experiment is, that this should continue to form so rapidly; as the effect was unceasing, and the quantity of hydrogen notable.

The last of these desultory experiments, with which I shall trouble you, is one, the unravelling of which cost me much trouble, and although ending in nothing very remarkable, a notice of it may save other experimentists a tedious research. When, with a very powerful voltaic battery, small wire electrodes of platinum are dipped into water acidulated with sulphuric acid, a brilliant combustion, attended with a decrepitating noise, is observed at the cathode, provided the anode be sufficiently immersed in the liquid; on inverting the arrangement, *i. e.* immersing the cathode and touching the surface with the anode, a slight spark only is perceptible; in both cases the heat is very intense, and the liquid boils at the point of contact, giving off sulphurous acid fumes; it would seem, at first, that this phenomenon was contrary to the usual fact observed in the voltaic combinations, viz. that the combustion is more active at the positive, than at the negative terminal: but I found it to be in reality no anomaly, as it is the sulphur of the dilute acid which is principally concerned in producing the brilliant effect at the cathode, and which, as it is evolved, forms itself the positive terminal. When the

Digitized by Google

experiment was continued for some time, a very dark chocolate powder was deposited in the liquid, and was found to be precipitated when ingredients of the utmost purity were employed. After various tests had been employed, this precipitate was ultimately found to be soluble in nitro-muriatic acid; the solution, treated with ammonia, gave a double salt of platinum, it also gave a precipitate with chloride of barium, the original deposit was, in fact, sulphuret of platinum. The gas evolved from the negative electrode in this experiment was hydrogen, mixed with sulphuretted hydrogen.

I trust this notice may not be too late for insertion in your next number, and remain, dear Sir,

Yours truly,

Sept. 18, 1843. W. R. Grove.

XXVI. *Description of Armstrong's Hydro-Electric Machine, as constructed on a large scale for the Royal Polytechnic Institution.* By the Editor.

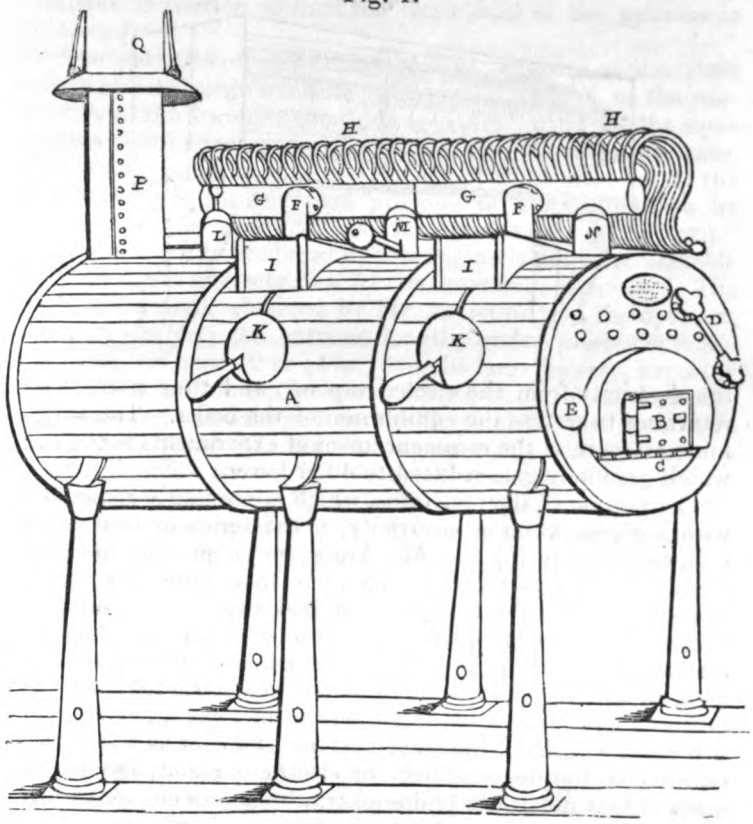
The directors of the Polytechnic Institution, in pursuance of their plan of presenting to the public every new and important feature in Experimental Philosophy, have just added to the attractions of their establishment, by erecting an engine of enormous power, for the production of electricity by the escape of steam. As a subsequent page of the present number of the "Electrical Magazine" contains an analysis of Prof. Faraday's "Researches" in this branch of the science, we gladly avail ourselves of the opportunity of referring our readers to his valuable paper, in place of entering ourselves on any extended explanation of the theory here. Suffice it, for our present purpose, to describe the engine and its action; and we are in some sort prepared for this from having been present at most of the experiments made, preparatory to the public exhibition of the engine.

Fig. 1 represents the engine, as it stands at the right hand side, on the floor of the large lecture-theatre. A is a cylindrical tubular boiler of rolled iron-plate $\frac{5}{8}$ in. thick; its extreme length is 7 ft. 6 in., one foot of which is occupied by the smoke chamber, making the actual length of the boiler $6\frac{1}{2}$ ft.: its diameter is $3\frac{1}{2}$ ft. The furnace B, and ash-hole C, are contained within the boiler; and are furnished with a metal screen to be applied for the purpose of excluding the light, during the progress of one class of experiments. D is the

Digitized by Google

water guage; E the feed-valve. F, F. are two tubes leading from the valves I I to the two tubes G, G. H, H are 46 bent iron

Fig. 1.

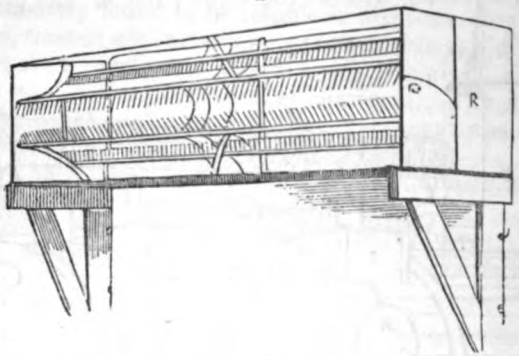


tubes, terminating in jets; either half or the whole of which may be opened by means of the levers K, K. L is a valve for liberating steam during the existence of the maximum pressure. M is the safety valve; N is a cap covering a jet, that is employed for illustrating a certain mechanical action of a jet of steam. O O &c. are six stout pillars of green bottle glass, by means of which the boiler is insulated at 3 ft. from the ground. P is the first portion of the funnel, Q the second portion, which slides into itself by a telescope joint, so that the boiler may be insulated when the experiments commence. The boiler is cased in wood to reduce radiation

Digitized by Google

of heat. Fig 2. is a zinc case, furnished with four rows of points, which is placed in front of the jets in order to collect

Fig. 2.



the electricity from the ejected vapour; and thus prevent its returning to restore the equilibrium of the boiler. The maximum pressure at the commencement of experiments is 80 lbs.; which gradually gets reduced to 40 or lower.

The portion of the apparatus, which is peculiarly connected with the generation of electricity, is the series of bent tubes with their attached jets. Mr. Armstrong, a professional gentleman of Newcastle, whose name is now quite familiar to the scientific world from his original experiments on this subject, very kindly superintended the structure of the boiler, and made repeated experiments, in many of which he was assisted by Capt. Ibbetson, in order to determine the most favourable conditions for obtaining the maximum effect. He had seen, with Prof. Faraday, that moist steam is absolutely essential to the developement of electricity; and, in compliment to that illustrious philosopher, who has so clearly shown that the phenomena are due to the friction of *watery particles*, he has named the apparatus "The Hydro-Electric Machine." Now, as high pressure steam is *dry* in the jet, which proceeds *directly* from the boiler, he has found a means of obtaining just sufficient condensation for the object in view, by interposing the bent tubes, H, between the boiler and the jets. For causes, which are not at present apparent, he found that tubes of lead or tin were far less efficient than those of iron. The *form* and *material* of the jet exercise very great influence over the results. He has found partridge-wood superior to any other material. The wood is formed into hollow cylinders; which are contained within a brass case. The steam is not permitted to have *direct* access to these cylinders from the

Digitized by Google

bent tubes; but impinges first on a metallic circle, and has to pass over the chord of a segment cut from the circle. By this contrivance, Mr. Armstrong is of opinion that a greater amount of friction against the inner sides of the cylinder is obtained.

The particles of water may be thus regarded as the glass plate of an electric machine; the partridge-wood, as the rubber; and the steam as the rubbing-power. And for the same reason that increased rapidity of rotation is, in the one case, favourable to an exalted developement of effects; so, in the other case, is the increased pressure of the steam, with its consequent increased frictional force and its rapidity of exit.

The electricity produced by this engine is not so remarkable for its high intensity, as for its enormous quantity. The maximum spark obtained by Mr. Armstrong, in the open air, was 22 inches; the extreme length, under present circumstances, has been 12 or 14 in.; but the large battery, exposing nearly 80 feet of coated glass, which, under favourable circumstances, was charged by the large plate machine 7 ft. in diam., in about 50 seconds, is commonly charged by the hydro-electric engine in 6 or 8 seconds. The sparks, which pass between the boiler and a conductor, are exceedingly dense in appearance; and, especially when short, more resemble the discharge from a coated surface than from a prime conductor.

In no case, antecedent to this, has the electricity of tension taken so rapid a stride towards assimilating with galvanic electricity. Mr. Faraday's experiments on the identity of the electricities,* had shown how small was the quantity obtained from the best machines; and had given good reason to expect that chemical effects would be exalted when the quantity could be increased. And such is the case here: a very remarkable experiment in illustration of this is that, not only is gunpowder ignited by the passage of the spark, but even paper and wood-shavings will be inflamed, when placed in the course of the spark, passing between two points. Such an effect was never before produced with common electricity. In like manner, chemical decompositions are effected much more readily by means of the hydro-electricity, than by that from the common machine. We have had the opportunity of witnessing these effects, and were very interested in the results, inasmuch as they come so strongly in confirmation of the views advanced by Mr. Faraday, and now generally adopted. A series of electrolytic effects are given in the last number of the

* Exp. Researches, Series 7, § 861.

Digitized by Google

"Philosophical Magazine," to which we refer. The current, when passed through a galvanometer, caused the astatic needle to oscillate between 20° and 30°; it also formed an electro-magnet, which deflected a needle. In these various experiments, care is taken to place the conductor, Fig. 2, very near the jets when quantity is required; and to remove it beyond the striking distance, when intensity is required.

The situation of this engine, in the same room with the Colossal Electrical Machine, furnished a very favorable opportunity, not merely of contrasting the effects of the two, but of employing them simultaneously. On placing the large battery on an insulating stool, between the prime-conductor and the boiler, and connecting the inner coating with the former and the outer with the latter, we several times failed in communicating a charge: on reversing conductors it was accomplished more readily; but in far longer time than would have been required by the boiler alone. Again, when the *aurora*, obtained by passing the electricity from the prime conductor through an exhausted tube 4 or 5 ft. in length, was contrasted with that produced from the electricity of the boiler passing through the same tube, the latter was by many degrees more brilliant; but, when the boiler was connected with one end of the tube, as it stood on an insulating stool, and the prime conductor with the other, the brilliancy greatly diminished. The first crude idea seemed to be that, if the earth in its *normal* condition could supply to the boiler electricity equivalent to the production of a certain effect in a certain time, the prime conductor in its *positively* charged state would produce a greater effect. But more mature reflection soon connected the fact of actual diminution of effect with the known laws: for, as the maximum supply of positive electricity which the conductor could furnish was at most not a *fourth* of that required by the negative boiler, and as the supply from the earth was *unlimited*, the whole equilibrium was restored in the one case, and only a portion of it in the other. Time did not permit the prosecution of these experiments; it is, however, very evident that, under such circumstances, the effects of the two instruments cannot be united; but, as there are blank jets provided, some future day may give an opportunity of using only a fourth of the jets, and then contrasting the separate with the united action of these two giant machines. The next three months cannot but be fertile in new facts connected with this engine, yet in its infancy; and we shall not neglect collecting them for the use of our readers. Mr. Armstrong has mentioned many anomalies, which have occurred to him in the course of his experi-

Digitized by Google

ments: these also will be acceptable additions preparatory to ultimate generalizations. C. V. W.

While this sheet was going through the press, we have had repeated opportunities of witnessing the progress made in getting the machine into working order. Mr Armstrong, whose able advice has materially facilitated the arrangement, assures us that the spark is not nearly so long as when the boiler was in the open air; and he conceives this to be due to the difficulty of getting rid of the steam; for when the box of points, Fig. 2, is removed to its maximum distance, (which is necessary when effects of tension are required,) a good portion of the steam is dissipated within the apartment.

We were present at the private exhibitions, on Thursday, Sept. 14th, and on the following evening to a meeting of men of science, and could not fail to remark the admiration with which its extraordinary powers were regarded by all. The first opening of the jets, with its attendant volumes of condensed sparks, gave rise to the very natural thought—Is it possible that we have lived so long amid such fertile sources of power without being aware of it!! This feeling seems equally shared by the crowds of visitors who daily frequent the theatre. We congratulate Mr. Armstrong on the perfect manner in which the machine is constructed; and we congratulate Dr. Bachhoffner, under whose control it is placed, on having the command of the most powerful electrical instrument in the world.

Since the above was written, the boiler has been furnished with a long brass telescope-rod, terminating in a large ball, and attached to the boiler by a universal joint,—this increases the facility of manipulating. It may not be amiss to add, that the Leyden jars are repeatedly broken during discharge; and that, during the interval required by the ball of a balance discharger to descend, the battery is often so overcharged as to give a spontaneous discharge over the glass.

We are glad at being able, almost before the ink was dry in our pen, to redeem the promise we gave of reporting any new facts. The following facts, containing, as they do, several anomalous results, have this moment been mentioned to us by Mr. Armstrong. In the present state of our knowledge, they must be taken as *absolute facts*, the cause of which is not at first apparent, and as such, are given without comment.

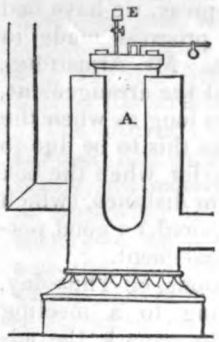
When the generator (Fig. 3),* which is a steam boiler, was

* Vide Proc. Elec. Soc. p. 528.

Digitized by Google

new, and the inner surface rough and oxydized, as it came from the mould, the electricity of the boiler was *negative;* but after using the apparatus for some time, it became by degrees *positive.* Drawing out the residual water, and replenishing with clean water, did not restore the boiler to its original electrical state; but washing it out with a solution of pearlash, again rendered it *negative,* and in a higher degree than it had been at first. On the other hand, a little nitric acid, mixed with the water, rendered the boiler *positive;* but neither sulphuric acid nor hydro-chloric acid had the same effect. Sulphuret of potash acted in the same manner as nitric acid, but in a higher degree. When I afterwards removed the rough oxydized surface of the interior with a boring tool, so as that a bright metallic surface should be presented to the water, the apparatus was always *positive,* whether any extraneous matter was mixed with the water or not.

Fig. 1.



The tendency to *positive* electricity in the boiler, always increased as the water subsided, and as the upper part of the boiler, where the steam was lodged, became, in consequence, heated. *Priming,* or the ejection of water from the boiler, in conjunction with the steam, always diminished the electricity, whether it were positive or negative, which at that time led me to suppose that the highest effect was attainable with *dry* steam.

I have frequently seen the apparatus change from a *negative* to a *positive* condition, as the water subsided in the boiler.

In all these cases the steam was discharged from a brass stop cock, or the brass safety valve attached to the apparatus; and I have repeatedly seen the steam from the valve *negatively* electrified, whilst that from the cock was *positively* so. I do not think I ever saw the boiler in a *neutral* state, except during the transition from one electrical state to the other. When a wooden mouth-piece was affixed to the stop cock, the steam from it was always positive, and the boiler negative, whatever the other conditions of the experiment might be.

These changes from one electrical state to the other, never took place with an iron boiler, except when the steam was conveyed from it into a separate chamber, and there impregnated with extraneous matter.

Digitized by Google

SCIENTIFIC METINGS.

ROYAL SOCIETY.

Experimental Researches in Electricity. Eighteenth Series. By MICHAEL FARADAY, ESQ., D.C.L., F.R.S., &c. Read: February 2d, 1843.

§ 25. ON THE ELECTRICITY EVOLVED BY THE FRICTION OF WATER AND STEAM AGAINST OTHER BODIES.

(*Abstract.*)

AFTER allusion to the original experiments of Mr. Armstrong, a description is given of the apparatus employed in the present researches, which was that already described in these pages.* The pressure of steam, at which the experiments were carried on, was from 8 to 13 in. of mercury;—never higher than 13. After giving the experiments, already before our readers, which show that neither mere evaporation, nor the friction of dry steam is the cause of the electric excitement, Mr. Faraday refers to the modification which increase of pressure will make in the results; for it "will sometimes change the positive power of a passage to negative; not that it has power of itself to change the quality of the passage, but, as will be seen presently, by carrying off that which gave the positive power; no increase of pressure, as far as I can find, can change the negative power of a given passage to positive." Then again, he speaks of the influence exercised by the shape and form of the exciting passage favouring more or less the contact and subsequent separation of the rubbing and the rubbed. The following experiment involves much information:

"If there be no water in the steam globe, upon opening the steam-cock, the *first effect* is very striking; a good excitement of electricity takes place, but it very soon ceases. This is due to water condensed in the cold passages, producing excitement by rubbing against them. Thus, if the passage be a stop-cock, whilst cold it excites electricity with what is supposed to be steam only; but, as soon as it is hot, the electricity ceases to be evolved. If, then, whilst the steam is issuing, the cock be cooled by an insulated jet of water, it resumes its power. If, on the other hand, it be made hot by a spirit-lamp before the steam be let on, then there is *no* first effect. On this principle, I have made an exciting passage by surrounding one part of an exit-tube with a little cistern, and putting spirits of wine or water into it."

Then follow the effects of imparting conducting power to the rubbing particles of water, by adding salts, acids, &c., and so destroying their exciting powers, which are thus explained:

"The effect is evidently due to the water becoming so good a conductor, that, upon its friction against the metal or other body, the electricity evolved can be immediately discharged again, just as if we tried to excite lac or sulphur by flannel which was damp, instead of dry. It shows very clearly that the exciting effect, when it occurs, is due to water and not to the passing steam."

* Ibid. p. 61.

Digitized by Google

The influence of the rubbed substances is next investigated by the successive employment of "cones of various substances either insulated or not; and the following, namely, brass, box-wood, beech-wood, ivory, linen, kerseymere, white silk, sulphur, caoutchouc, oiled silk, japanned leather, melted caoutchouc, and resin all become negative, causing the stream of steam and water to become positive." The rubbed substances were likewise examined by placing them on insulating handles, and holding them in the jet. Of thirty substances thus tried, *all* were rendered negative though not in the same degree; for instance, "quill and ivory had very feeble powers of exciting electricity as compared to other bodies." To prevent condensation, a platinum wire, rendered incandescent by an insulated voltaic pile, was placed in the jet;

"No difference was visible between the effect of the first instant of introduction or any other time. . . . The string or thread, if held exactly in the middle of the jet, and looked at end-ways to the thread, was seen to be still; but if removed the least degree to the right or left of the axis of the stream it (very naturally) vibrated, or rather rotated, describing a beautiful circle, of which the axis of the stream was the tangent: the interesting point was to observe that, when the thread rotated, travelling as it were with the current, there was little or no electricity evolved, but that, when it was nearly or quite stationary, there was abundance of electricity, thus illustrating the effect of friction."

Mr. Faraday then alludes to the almost neutral effect of some bodies, especially ivory, already mentioned, and shows how it enabled him to test the series of substances by furnishing him with a neutral jet. He then adverts to effects produced by a positive jet, "which, if not understood, would lead to great confusion;"—that a wire gauze, for instance, when in the jet *near the exit*, is rendered negative; because, as he explains, under such circumstances it is forcibly rubbed by the issuing stream; but if *further removed*, it is made positive, acting then only as a collector from the already excited steam; there is also a neutral point. These converse effects do not occur with a neutral stream from an ivory jet. Having made the liquid in the steam globe slightly conductible, it was found to have a neutral effect on all the bodies previously tried; but Mr. Faraday does not hence make any hasty inference: he says, "Very probably great increase of pressure might have developed some effect." He adds:

"With dilute sulphuric acid in the steam-globe, varying from extreme weakness to considerable sourness, I used tubes and cones of zinc, but could obtain *no trace* of electricity. Chemical action, therefore, appears to have nothing to do with the excitement of electricity by a current of steam."

The remarkable circumstance of water being *positive* to so many bodies, is then noticed; as also the probability that it may "find its place above all other substances, even cat's hair and oxalate of lime."

The effect of oil of turpentine in producing negative electricity in the steam, and positive in the boiler, is next described. The transient character of this new effect, in consequence of the speedy dissipation of this volatile oil, was contrasted with the more perma-

Digitized by Google

nent effect produced by the use of fixed oil, as olive oil. "Hog's lard, bees-wax, castor-oil, resin applied dissolved in alcohol, these, with olive oil, oil of turpentine, and oil of laurel, all rendered the boiler positive, and the issuing steam negative." Some substances give variable results; but, it is easy to comprehend that, according as a substance may adhere to the body rubbed, or be carried off by the passing stream, exchanging its mechanical action from rubbed to rubber, it would give rise to variable effects." The readiest method of obtaining permanent *positive* effects in the boiler is by putting a little oil or wax into the steam globe, or a thick ring of string or canvass soaked in wax, or in solution of resin or alcohol, into a box substituted for the globe. These effects of oil invole the necessity of attention being paid to the condition of the screws connected with the various passages; for the unsuspected presence of a little oil may mar the effect of every arrangement. Oil of turpentine blown through a foul jet, is given as a successful means of purifying it. Oils, in conjunction with water previously neutral by being made conducteous, have the effect of rendering the boiler positive, but in a less degree than when pure water is used: "increase of the force of steam, as in all other cases, would, there is little doubt, have exalted it again." Oil and resin lost very *much* of their power when alkali was in the steam-globe; oil of turpentine very *little*.

The author then goes on to explain how the introduction of oil virtually converts the watery globules, so far as their rubbing surface is concerned, into oil globules,* by forming a film on their surface; and this too, explains the "fact that alkalined water, having no power of itself, should deeply injure the power of olive oil or resin, and hardly touch that of oil of turpentine; for the olive oil or resin would no longer form a film over it, but dissolve in it; on the contrary, the oil of turpentine would form its film." And he adds that when wood, or glass, or even metal, is rubbed by these oily currents, the oil may be considered as not merely rubbing against these substances, but against water also, for which they have a superior attraction; and in this case the positive state of the rubbed substance, and the negative state of the rubbing stream, would be exalted.

Conceiving thus that steam, as such, was merely the mechanical agent to carry onward the rubbing particles, Mr. Faraday proceeded to experiment with compressed air, condensed into a strong copper box, which had been previously carefully cleaned from all traces of oil by caustic potash: the average quantity of air which could be issued at each blast was 150 cubic inches. When common *undried* air was used, it rendered the cone negative, exactly as the steam and water had done.

"This," as the author expresses it, "I attribute to the particles of water suddenly condensed from the expanding and cooled air rubbing against the metal or wood: such particles were very visible in the mist that appeared, and

* Vide Elec. Mag. p. 63.

Digitized by Google

also by their effect of moistening the surface of the wood and metal. The electricity, here excited, is quite consistent with that evolved by steam and water: but the idea of that being due to evaporation is in striking contrast with the actual condensation here."

When such air was blown against ice, the ice, *i. e.* the *frozen water*, became *positive*, strongly in accordance with the high positive position already assigned to water.

When the same experiments were repeated, with *dry* air (dried by having placed potassa fusa in the box) it was found quite *incapable* of exciting electricity, precisely as had been proved to be the case with *dry steam*. The introduction of water, saline, or acid solutions, or the oils, in the course of the stream of common air, produced exactly the same effects "as if these substances had been carried forward in their course by steam."

A few experiments were tried, in conclusion, with the air current and dry powders. The results were somewhat irregular from the very nature of the rubbing materials; for in some cases they adhered to the cones and became the rubbed; besides presenting other interfering powers. Sublimed sulphur rendered cones of metal, of wood, and even of sulphur, negative; once only it rendered metal positive: powdered resin *generally* rendered metal negative, and wood positive: starch made wood negative: silica made metal or wood strongly positive.

A certain ivory tube, which had been used for many experiments with oil, resin, &c., is described as having acquired and retained, although it had been afterwards soaked in alcohol, not only a *non*-exciting state, but even a *nullifying* power; so that the stream which passed through it, "produced no excitation against any of the bodies opposed, as on the former occasions."

The memoir is terminated with the following deduction:

"Finally, I may say that the cause of the evolution of electricity by the liberation of confined steam is not evaporation; and further, being, I believe, friction, it has no effect in producing, and is not connected with the general electricity of the atmosphere: also, that as far as I have been able to proceed, pure gases, *i. e.*, gases not mingled with solid or liquid particles, do not excite electricity by friction against solid or liquid substances."

BRITISH ASSOCIATION.

On a New Electrical Machine, and upon the Electricity of the Atmosphere. By Mr. Nott. Read at Cork, August 18, 1843.

Ths Paper treated at great length of electrical currents, and of the atmospheric electricity, by way of a preliminary to the consideration of terrestrial magnetism. The author insisted on the close analogy between the voltaic pile and a magnet. The difference between voltaic and frictional electricity he conceives to be, that the former is *in* the conducting wire, the latter *on* its surface, and therefore decomposed by whatever approaches it. Besides, the voltaic pile exhibits the two electricities and the current in which they unite; whereas the ordinary frictional machines develope and maintain but one electricity and no current. Among the novelties

Digitized by Google

presented by the paper, may be mentioned the description of what the author calls the rheo-electric machine, in which both electricities are developed by friction. "It consists of a circular plate of glass and another of resin, both supported upon a horizontal axis, and set in motion by a winch handle; the rubber of the vitreous plate is connected by a metal rod with the rubber of the resinous one; and the conductor of the latter plate is also connected by a metal rod with that of the former, and thus a complete circuit is formed, as in the voltaic pile. The distribution of the electricity of this instrument is also analogous to that of the pile. For example, the electro-motive disturbance is produced by the plates; the rubber of the vitreous plate is rendered negative, that of the resinous one, positive; and the conductors are also in opposite electric states, and their remote extremities are therefore analogous to the poles of the pile. When the conductors are connected by a conjunctive wire, it is natural to suppose that the accumulated electricities flow along its surface in opposite directions; for then an electric current is formed, which permanently deflects the magnetic needle, and the deflection is according to the direction of the current. The direction of motion of this current may be varied at pleasure; for instance, in order to fix our ideas, let us suppose the plates of this instrument and the axis of the conductors to be lying in parallel planes, perpendicular to what is called the magnetic meridian, the conjunctive wire connecting the conductors being bent at right angles, a portion of it will then be in the meridian, and the metal rod connecting the rubbers will be parallel to this portion. If now a magnetic needle be suspended above the conjunctive wire; and the resinous plate, which we will suppose to be placed north of the vitreous one, be connected with the earth, then a current of electricity passes from the resinous plate, and consequently flows along the conjunctive wire from north to south; the needle is then permanently deflected towards the west. If the needle be placed beneath the conjunctive wire, the deflection is towards the east. When the vitreous plate is connected with the earth, the current flows from the vitreous plate, and the deflections are in the opposite directions." In the course of his experiments with this machine, the author found that all the parts of it, which were made of brass, became, by electrization, highly magnetic, and retained their magnetism for some time. The character of the magnetism thus produced will be understood by conceiving an orthographical projection of this instrument, to be drawn upon a horizontal plane: it will be a parallelogram, of which the conjunctive wire will form one side, and the rod connecting the rubbers another: then all the brass parts of one half of this parallelogram, cut off by a diagonal line, will attract the north pole, and all of the other half, the south pole. But if, immediately after electrization, either pole of the needle be forced into contact with any part of the brass conjunctive wire, it will develope an opposite magnetism to its own, and adhere to the wire as it would to a piece of iron. He also proved that water may

Digitized by Google

be decomposed by the rheo-electric machine, as with the galvanic current. The two electricities, as developed by this machine, appeared to him to be visibly different; the resinous electricity was subject to remarkable changes of colour, according to the state of the atmosphere, and the nature of the exciting body. It also struck him that electricity is radiated in a peculiar manner from magnetized bodies. Combining this observation with an hypothesis respecting the electricity of the globe, viz. that the equatorial parts of the earth are in the resinous, (in old language, negative) state of electricity, the poles vitreous (positive); while the atmosphere is, in its lower strata, vitreous, and in the upper resinous; the author proceeds to exhibit the phenomena of the aurora borealis by direct experiment. "I procured a globe of steel and magnetized it. It may not be unnecessary to state how this was effected. I suspended the globe upon an axis, and, by a multiplying wheel and pulley, set it in rapid rotation; while rotating I made the magnetizing bars traverse from the equator of the globe to the poles. I then tested it with a proof needle, and found it to be regularly and perfectly magnetized. The next object was to place this magnetic globe in similar electric circumstances to those which I conceived the earth to be in. Regarding that region of atmosphere, immediately over the torrid zone, as the principal seat of atmospheric electricity, I conceived that, if I surrounded the globe with a ring that would bear approximately the same proportion to the globe, as this region of atmosphere does to the earth, and electrized them oppositely, that the action of the electricity of the ring upon the air immediately enveloping the globe, would place the latter in nearly similar electric circumstances to those of the earth. If, then, the aurora were an electric phenomenon, that is a discharge of free electricity taking place from the pole of the earth, rendering the vortex, which I supposed to be immediately over the pole, luminous, from the great rarefaction of the air within it, and passing over our atmosphere to the upper stratum of the equatorial region, that, as I could increase the electric intensity of my artificial terrella as I pleased, an analogous effect would be produced. This result followed with the greatest precision, as I shall now describe. I insulated the ring, and connected it with the resinous conductor of the rheo-electric machine. I also insulated the globe, and connected one of its poles with the vitreous conductor, and placed it so that its equator was surrounded by the ring. These bodies being electrized differently, and at a very short distance from one another, one would expect that a discharge would have taken place between them; instead of this, they at once reacted upon one another, so that the exterior of the ring became resinous, the interior became vitreous; the equator of the globe resinous, and both its poles highly vitreous; and a truly beautiful and luminous discharge took place from the unconnected pole. The state of the atmosphere has a remarkable effect upon the appearance of this discharge. One evening that the atmosphere was very dense,

Digitized by Google

it had the appearance of a ring of light, the upper part of which was very brilliant, and the under part, towards the globe, was comparatively dark, just as we see at the bottom of ignited vapour; and indeed a vapour of some kind seemed to be ascending from the globe; above the ring, all round the axis, were foliated diverging flames, one behind the other. When the atmosphere is very dry, it has merely the appearance of a beautiful electric brush. If the globe be moved towards any point of the interior of the ring, a discharge takes place in the line of shortest distance between them, and then there is a partial imtermission of the auroral light. This experiment seems to point out the true cause of the aurora borealis."—*Athenæum*, Sept. 2.

Electro-telegraph Thermometer for the Captive-Balloons. By Prof. Wheatstone. Read Aug. 19, 1843.

The telegraph thermometer, which is intended to be carried up by the balloon, weighs, with its case, about four pounds. It is thus constructed; the movement of a small clock causes a vertical rack to ascend and descend regularly in six minutes, three minutes being occupied in the ascent and three in the descent. The rack carries a fine platinum wire, which moves within the tube of a thermometer; the extent of motion of this wire corresponds with 28° of the thermometric scale; but it is capable of adjustment, so that it may pass over any 28° of the range. Two very fine copper wires, covered with silk, and of sufficient length to reach from the ground to the balloon, when at its greatest elevation, are connected with the instrument in the following manner: the extremity of one wire is connected with the mercury in the bulb of the thermometer, and that of the other wire with the frame of the clock, which is in metallic continuity with the platinum wire. On the ground, the lower extremities are joined together; in the wire, whose opposite end is connected with the mercury in the thermometer, a sensible galvanometer is interposed; and, in the course of the other wire, a single, very small voltaic element is introduced. The galvanometer having been properly adjusted to its zero point, it will remain so during the time that the platina wire is not in contact with the mercury in the tube, but the needle will deviate so soon as the contact takes place, and will remain deflected until contact is again broken during the ascent of the rack. During each half second of time, corresponding with the beats of the clock, the wire moves through the 360th part of its range, and a different point of the range consequently corresponds with a different beat, or half second of each alternate three minutes. If, therefore, an observer below be furnished with a chronometer, timed to coincide with the clock in the balloon above, and note at what instant the needle of the galvanometer is deflected, he may infer from that observation the temperature indicated by the thermometer in the balloon: for, according to the different expansion of the mercury in the ther-

Digitized by Google

mometer, the contact is broken at a different half second. Should the rates of the two time-pieces not exactly correspond at the conclusion of a series of observations, the results will not be vitiated, as a correction will be easily made. It is intended to add to this apparatus a wet-bulb thermometer; this will involve only the addition of another platinum wire to the rack, and of another insulated wire, reaching from the balloon to the earth, with its interposed galvanometer.

For other meteorological instruments, the indications of which are to be transmitted to a distance, I occasionally employ the agency of electro-magnetism to ring a bell, to mark with a type, or pencil, &c.; but, for the purpose in question, such methods cannot be so conveniently employed as the deflection of the needle of a galvanometer, on account of the necessity of having the long conducting wire extremely fine, in order to avoid adding too much to the weight of the balloon. If the electromotive force of the rheomotor were increased, which it would be necessary to do were stronger currents required, sparks would occur at the surface of contact of the mercury, which would produce injurious effects.—*Athenæum*, Sept. 2.

On the Circumstances which affect the Energy of Artificial Magnets. By the Rev. W. Scoresby, D.D. Read 21st Aug. 1843.

"The object of this communication, Dr. Scoresby stated, was not to enter into the extensive bearings of the subject announced, which the time of the section would not allow; but he might just state, in general terms, that the energy of permanent artificial magnets, of which alone he designed to speak, was affected by a considerable variety of circumstances, all acting by laws peculiar to themselves, and thus occasioning differences in the result and energy whenever any of the circumstances might be changed. These circumstances comprised quality of steel, denomination, (such as cast-steel, shear-steel, and blister-steel, &c.) temper or hardness, mass, and form. Hence, from the varying influence of these several circumstances, it was impossible to give a general answer to the enquiry, as to the best kind and temper of steel for permanent magnets. In large magnets, indeed, consisting of several combinations of bars or heavy masses, he, Dr. Scoresby, had sufficiently determined the fact, that best cast steel, made as hard as possible, was the most effective; but, for small magnets or thin compass needles, other steel, or cast steel tempered, became most effective. In a six-inch bar which he exhibited, of 600 to 700 grains weight, hard cast steel was advantageously employed; but in thin plates, used singly or in pairs, such hardness required to be reduced. But by extensive investigation of the effects of these several conditions, if any particular case were stated, he could easily determine the requisite qualities. That the power of a

Digitized by Google

magnet was essentially dependent on both *quality* and *hardness*, he, Dr. Scoresby, proceeded to show, by experiment with four small bars of similar size, but different qualities or tempers. One lifted only 600 grains, another about 1000, another the same, another 3,200 grains. Tried by Dr. Scoresby's mode of testing, described last year, he found the first to be bad in quality; the second inferior, and too soft; the third good in quality, but not hard enough; the last excellent in quality and hardness. On being laid in succession upon the test bar, the first three lost all their power, whilst the last retained still the power of lifting a key 3,200 grains weight. Two anomalies in practical magnetism were then described. First, the experimentally determined fact, that proportional magnets of similar steel and temper, were not energetic proportionally with their masses; in other words, that two magnets, one, for instance, being double in all its dimensions of the other, would not exhibit powers corresponding with their masses, or in proportion to the cubes of their lengths,—the proportions instead of being as $1^3 : 2^3 = 8$, would perhaps be found to be as 1 to 5 or 6 only. Hence it would be inferred that magnets could not be advantageously enlarged to an indefinite extent; at the same time, from the experiments already made, he, Dr. Scoresby, would have no difficulty in constructing a magnet of a ton weight, and, by means of his peculiar test (which he exhibited to the section,) of rendering every bar effective. The other anomaly to which he referred, was that arising out of difference of form. In all his experiments on more than 1,000 bars or plates, he had always found that extreme hardness was the most effective in large or considerable combinations of straight bar magnets. His surprise was therefore great, on trying the same principle on two horse-shoe magnets of five and fifteen bars, to find that the same laws did not prevail. The magnets, until reduced in temper, were of low power. To reduce them by a fixed and determinate rule, he, Dr. Scoresby, adopted a bath of oil, boiling at about 600°. He tried the effect of various temperatures, from 300° to the boiling, and thence determined the ratio of improvement until he obtained the best. The magnets annealed ultimately at a uniform temperature of 505° now exhibited very superior powers,—lifting from seven to nine times their own weight.

"In reply to a suggestion by the Dean of Ely, that 'unless Dr. Scoresby took the trouble of reducing these valuable observations to some more permanent form, and publishing them, they would be lost;' Dr. Scoresby said 'that he had tabulated the results, and laid before the Physical section at Manchester, diagrams, which placed before the eye at a glance the most important of these results, and that he was making preparations to publish them in a separate form.' Another object which he contemplated, was the connection of the best form of magnet with the economical production of power; and he had little doubt that the magnet would yet be used for the production of motive force. Whenever that was

Digitized by Google

the case, he felt assured the permanent magnet would be found more economical than the galvanic battery. As matters stood, even now he could engage to produce, if required, a magnet of over a ton weight."—*Athenæum.*

On the Calorific Effects of Magneto-Electricity, and the Mechanical Value of Heat. By J. P. Joule. Read 21st Aug. 1843.

"Although it has been long known that fine platinum wire could be ignited by magnetic electricity, it still remained a matter of doubt whether heat was evolved by the *coils* in which the magneto-electricity was generated; and it seemed, indeed, not unreasonable to suppose that *cold* was produced there, in order to make up for the heat evolved by the other parts of the circuit. The author had endeavoured, therefore, to clear up this uncertainty by experiment. His apparatus consisted of a small compound electro-magnet, immersed in water, revolving between the poles of a powerful stationary magnet; the magneto-electricity developed in the coils of the revolving electro-magnet, was measured by an accurate galvanometer; and the temperature of the water was taken before and after each experiment by a very delicate thermometer. The influence of the temperature of the surrounding atmospheric air, was guarded against by covering the revolving tube with tin-foil, &c.; and by the adoption of a system of interpolation. By an extensive series of experiments with the above apparatus, the author succeeded in proving that heat *is* evolved by the coils of the magneto-electrical machine, as well as by any other part of the circuit, in proportion to the resistance to conduction of the wire and the square of the current; the magnets having, under comparable circumstances, the same calorific power as the voltaic electricity. Prof. Jacobi, of St. Petersburgh, had shown that the motion of an electro-magnetic engine generates magneto-electricity, in opposition to the voltaic current of the battery. The author had observed the same phenomenon on arranging his apparatus as an electro-magnetic engine, but had found that no additional heat was evolved on account of the conflict of forces in the coil of the revolving electro-magnet, and that the heat evolved by the coil remained, as before, porportional to the square of the current. Again, by turning the machine contrary to the direction of the attractive forces, so as to *increase* the intensity of the voltaic current by the assistance of the magneto-electricity, he found that the evolution of heat was still proportional to the square of the current. The author discovered, therefore, that the heat evolved by the voltaic current is invariably proportionate to the square of the current, however the intensity of the current may be varied by magnetic induction. But Dr. Faraday had shown that the chemical effects of the current are simply as its quantity. Therefore he concluded that in the electro-magnetic engine, part of the heat, due to the chemical actions of the battery, is lost by the circuit, and converted into

Digitized by Google

mechanical power; and that when the electro-magnetic engine is turned *contrary* to the direction of the attractive forces, a *greater* quantity of heat is evolved by the circuit than is due to the chemical reactions of the battery, the overplus quantity being produced by the conversion of the mechanical force exerted in turning the machine. By a dynamometrical apparatus attached to his machine the author ascertained that, in all the above cases, a quantity of heat, capable of increasing the temperature of a pound of water by one degree of Fahrenheit's scale, is evolved with the magnetism which possesses a force sufficient to raise a weight of about 874 pounds to the height of one foot."—*Athenæum.*

REVIEWS AND NOTICES.

An Account of some remarkable Applications of the Electric Fluid to the Useful Arts, by Mr. Alexander Bain, with a Vindication of his Claim to be the first Inventor of the Electro-Magnetic Printing Telegraph, and also of the Electro-Magnetic Clocks. By John Finlaison, Esq., Actuary of the National Debt Office, and Government Calculator. London: Chapman and Hall, 1843.—1 vol. 8vo. plates, &c., pp. 127.

Had this book no other claim to public notice than is conveyed in the latter clause of its title, its contents would little concern the man of science. He cares not to stand as adjudicator in the cause of contending rivals; nor is it consonant with his feelings to view the bitter revilings which pass between the angry disputants. Our readers may remember that in the months of June and August, 1842, several letters appeared in the *Literary Gazette*, on the one hand from Mr. Wheatstone, and, on the other, from Mr. Bain; and that the editor very consistently refused his columns for a continuation of the controversy. The subject is renewed in this book. We cannot congratulate Mr. Bain on the manner in which his claims have been advocated: however much he may think himself wronged,—and however deeply his feelings may have been wounded by the sense of his unmerited neglect, we are quite sure that the great want of courtesy displayed in every page of Mr. Finlaison's work will induce many to close the volume without doing justice to the young man, in whose behalf it is penned. The author has been "zealous overmuch;" in his ardour to maintain the rights of his fellow-townsman, he has outstripped his better self, and has so interwoven the plain statement of the case with sarcasm and "railing accusation," that it requires some attention to divide, to use our author's own language, "the *esse* from the *posse*." We write this in all kindness to Mr. Bain; for this reiteration of personal recrimination gives a repulsive character

Digitized by Google

to his cause, which "a plain unvarnished tale" might not present. The tedium too, and constant repetition of the same charges, and the same evidence only weary the reader without strengthening the case.

The following extract will exhibit the cause of contention, and will illustrate our allusion to the introduction of the *posse* among the *esse:*

"But to return to Professor Wheatstone, who had thus obtained *an idea*—nothing more—an idea of telegraphing time — a vague notion of applying electricity to work clocks, after the same thing had been actually done by another, and the fact widely published. The Professor was unable to work out the *idea*, until after the 18th of August, 1840, when Mr. Bain showed him *how it was to be done:* he then went "a-head" famously, and by the following November managed to get an electro-magnetic clock finished agreeably to Mr. Bain's pattern, but with one important difference ; for Mr. Bain did not show the Professor how he intended to make and break the circuit, and in this part he was left to shift for himself: he soon supplied what was wanting, however, by the introduction of his *rheotome.* Whether it was from sheer want of mechanical skill, or from subtilty, in order to create an apparent resemblance between his electric clock and his telegraph, it is hard to say ; but he did commit the mechanical absurdity of placing his *rheotome* on the *escape-wheel* of the clock!"—p. 104.

"Professor Wheatstone's claim to the invention of the Electro-Magnetic Printing-Telegraph requires a few words. The Professor endeavours to show, that he had the *idea* of such a contrivance previous to his interview with Mr. Bain. No doubt he had ! and from whence did he get it ? Was it from Morse, the American Philosopher, who was engaged from 1832 to 1837, in working out the *idea*, when it was published to the world,—where the signals were actually marked in lines on paper placed for the purpose ? or, did he take the *idea* from Mr. Davy's patent of 1838, where the signals were actually marked in dots on the revolving cylinder? . . . The Professor would hardly venture to deny his acquaintance with the former, after its extensive publication in the old as well as the new world; acquaintance with the latter he cannot deny, as he harassed Mr. Davy for several months before the Solicitor-General, in opposing his patent," &c. . . . . "Mr. Bain's Electro-Magnetic *Printing* Telegraph consists of three principal parts, to none of which is there the slightest resemblance in any one of the patented contrivances of Mr. Wheatstone, *prior to the latter's acquaintance with Mr. Bain.*"—p. 106.

Now, were the inventions in question purely matters of priority in a *scientific* sense, our time might be justly employed in analyzing the rights of the respective claimants; but they are without the pale of the tribunal of science: the Professor, in the case before us, has laid aside his gown,—he has stepped from his chair into the shop of the artisan. His discoveries there are not treasures presented to the scientific world, they are riches heaped up for his own private emolument: his labours there are not directed to the increase of his reputation as a philosopher, but to the increase of his wealth as a citizen. If the term "*working* mechanic" is due to the young stranger from Caithness,—though we think his evident talent and ingenuity give him claim to a higher title than the ordinary acceptation of that term conveys,—if it is due to him, is it not equally appropriate to his illustrious compeer?—*compeer*, we say, because, when a philosopher avails himself of the protection of the Patent Laws, he *loses caste* as a philosopher, and descends to an equal rank with all others who

Digitized by Google

seek the protection of the same banner. As the case then is not one in which two philosophers are contending for the wreath of laurel, but one in which two traders are struggling for the circlet of gold, we are right glad to take shelter within the Temple of Science, and leave to other tribunals their native right of passing judgment.

Setting aside then the *legal* right, there is a *moral* right which is, in the abstract, of far higher value: the latter is essentially the true right, even though it cannot be converted into the former. Now it would seem that on Aug. 1st, 1840, Mr. Wheatstone listened with profound attention and apparent surprise to Mr. Bain's disclosures relative to his Clock and to his Printing Telegraph, *without giving any hint that he was himself then occupied with similar projects.*

Dismissing, therefore, all concern as to whether the Professor *was* thus occupied as he states he was, or *was not*, as Mr. Bain endeavours to show, it seems evident, by the consent of all parties, that there was a candour and confidence displayed on one hand which were anything but returned on the other. We cannot for a moment question a man's right to keep secret the invention on which he is occupied; but we doubt his right to listen to the communication of another, who is engaged on the same subjects, without giving him that kindly caution which their relative position demands.

The following passage from Mr. Finlaison's book requires some comment (p. 28):

"The delay occasioned by all those movements, however, retarded the affixing the great seal [to Mr. Bain's patent including the employment of the earth* as part of the conducting and generating medium] until the 27th of May last, [1843.] On the 31st of May, the writer left for the distinguished member of the Royal Society, who had promised to present it, the paper and the diagram, which has just now been laid before the reader. It was returned next day with the following laconic epistle:

"1st *June*, 1843.

"Dear Sir,—I am sorry I must decline presenting the paper of your friend.

"I am, Dear Sir, Yours faithfully,

* * *"

"How bitterly is the loss of Sir Joseph Banks, that generous and noble-minded friend to real merit, to be deplored in these days!

"Does the reader require to be told by whose influence it was that the gates of the very temple of science itself are thus barred and bolted against Mr. Bain? *Mr. Charles Wheatstone is himself one of the council of the Royal Society.*"

For the sake of the Royal Society and those illustrious men who form its councils; for the sake, too, of the amiable philosopher from whom the said laconic epistle evidently comes, our readers ought to be reminded that the great seal had been affixed to Mr. Bain's patent of the discoveries contained in the paper on the 27th of May, being *before* the paper was sent to the "distinguished member of the Royal Society." Is it to be wondered at that he declined presenting it? It had then ceased to be a scientific communication; the discovery had been made a matter of merchandise,

* Vide Elec. Mag. p. 52.

Digitized by Google

and the paper was nothing beyond a copy or an abstract of the specification, and as such was justly excluded from admission. We know not the laws which govern those councils, but, had we a voice there, it would have been given *in toto* against reading a paper, which had been previously appropriated elsewhere; and we have good reason to believe that, had the shade of Sir Joseph been present, his vote would have been with us.

These and many similar observations cool the interest of the reader in behalf of Mr. Bain, and have doubtless induced many to close the book without caring to investigate the matter. The reasonable impression to such might be that a cause *thus* advocated cannot be very stable. We value the book then, not for any intrinsic merit it possesses *per se*, nor yet for the philosophy it contains, for the writer is evidently no electrician, as pages 34 and 35 bear witness; but we prize it as a condensed history of Electro-Telegraphs, presenting in a few pages, the improvements which have been gradually introduced into these instruments. The ulterior intent of the work is a guarantee to the reader that the best diligence of the author has been exerted to congregate all the facts he could gather; and in no other publication can we look for so many data on the rise and progress of electro-telegraphs. There are several folding plates illustrative of the instruments in their various stages of improvement which add to its historical interest; on which accounts, therefore, we recommend it to our readers.

On the Nature of Thunder-Storms; and on the Means of Protecting Buildings and Shipping against the destructive effects of Lightning. By W. Snow Harris, F.R.S. London: Parker, West Strand, 1843. 1 vol. 8vo. plates and wood-cuts, pp. 226.

While the experience of every summer is demonstrating the feeble tenure on which the security of every unprotected building rests, when the gathering storm-clouds float forward replete with their destructive artillery, — while scarcely a single lightning storm occurs without leaving behind deeply rooted traces of its visit, it is strange in the extreme that public anxiety is not roused from its lethargy to regard the adoption of measures, which may avert such dire visitations. Not to mention the many lightning accidents, which have occurred of late in the provinces and on our coasts, let us take but a glance at our own metropolis, and regard how much destruction has occurred within its comparatively limited bounds, during the last few years. Scarcely had we begun to forget the damage done to Spitalfields Church, than we are again reminded, by the destruction of the beautiful spire of St. Martin's, of the terrors pent up in the storm-cloud:—scarcely is the spire of Streatham Church rebuilt, and furnished with a protecting-rod, than its near neighbour Brixton Church, mounted on a hill and unprotected, suffers severely from another storm. It is said that the annual damage done by lightning, in England alone, cannot

Digitized by Google

be far short of fifty thousand pounds. And yet how little is the moral of these severe lessons regarded! In most cases, the particular building that has suffered from lightning, as the steeple of Streatham or that of St. Martin's Church, on its being restored, is furnished with those protecting means, which, had they been applied earlier, would have averted the destroyer; but, it would be a singular exception to a very general rule, to find the warning heeded in respect to other neighbouring buildings, which have stood scatheless. No: a kind of apathy prevails,—a sort of feeling that, having stood the brunt of many a furious storm year after year, it will still stand safe. And hence it is that most of our steeples, (we allude to them especially because the character of their structure renders them, as experience shows, peculiarly liable to be selected as the discharging channel of a lightning-cloud,)—that most of them are exposed to the pitiless fury of every consecutive storm. The statistics of the condition, in regard to provision against lightning, of the lofty buildings in this kingdom, would present a sad contrast to the immense and prudent outlays incurred to remunerate against damage by fire. Scientific considerations, which seem too to be sanctioned by experience, would lead us to suppose that the danger to the elevated buildings in large towns is enhanced of late years: for, in such towns, a large portion of the area is veined with the metal pipes of the gas and water companies, the inductive, as well as the conducting power of which, cannot but increase the electric tension of the super-posed cloud, and its tendency to discharge there rather than elsewhere.

We are surprised that architects do not pay more attention to the nature of lightning discharges. An elevated building should be considered by them as incomplete without its lightning-rod: it ought most assuredly to form part and parcel of their plans. Instead of this, what do we observe? We see metals placed in such position, that no human skill could devise better means for the destruction of the building, should a lightning-stroke unfortunately assail it. Is it that they argue on past safety as the security for future? Or is it that the study of electrical phenomena forms no part of an architect's education? If the latter, it is high time for a reform,—it is high time that the public money expended on public buildings, (for the elevated and exposed buildings are for the greater part public property,) should be invested on better security than the mere chance of the storm passing by it in safety. We may smile at the Thracians shooting their arrows against the thunder-cloud; and ridicule Augustus in his seal-skin cloak; but the smile and the sneer are far more the due of him of our own highly enlightened days, who stands on the ruin of that edifice, which in the day of prosperity he disdained to protect.

The young architect, and not he only, but all concerned in the preservation of the buildings we refer to, and all who value the wealth of their country,—for be it remembered that every article, which parts from our possession without an equivalent being re-

Digitized by Google

ceived, is a diminution from our wealth,—each can safely take Mr. Harris's work as a text-book. He will find there the general theory of thunder clouds and lightning discharges, and will see it brought into practice in the application of the principles to the erection of lightning-rods possessing the requisite conditions of perfect security. The treatise is also valuable as a book of reference; for it contains descriptions of the most important cases, which are on record, of accidents by lightning. These are compiled with much diligence, and from many sources; not a few are taken from Arago's excellent treatise in the Annuaire of 1838; and these are the more valuable, because copies of Arago's work are getting very scarce.

We are not prepared entirely to coincide with the theoretical views of our author; indeed he himself says (p. 66) that "although these views of the nature of electrical action in thunderstorms, are based upon very strong evidence from facts, they are, nevertheless, not so completely verified as to be entirely without the region of hypothesis;" but to the practical application of these views to the erection of conductors for buildings, we are prepared to give our full assent. Mr. Harris's "Conditions requisite to perfect safety," embrace the same general elements, as are contained in those of Gay-Lussac, and others who have written on the subject; he does not enter so minutely into the detail of the artizan's part in the matter, as does the French philosopher; but this is no fault; for it seems to us that quite enough is given to guide any one in the mere mechanical adjustment of the several parts, which indeed must vary very greatly according to circumstances. His "conditions" contain one element, which, important though it is, does not appear to have suggested itself to any who have been before him. He says, p. 100,—

"In estimating the resistance of a metallic body to the transmission of a shock of electricity, we have also to take into consideration the distance traversed. Now the resistance to electrical transmission through a metallic wire, has been found to increase with the length of the wire; that is to say, the resistance to the transmission of the charge was twice as great when the length of the conductor was doubled; a law observable from one hundred up to one thousand feet in length. A lightning-conductor, therefore, should have its dimensions increased, when required to be of considerable extent."

When, therefore, Mr. Harris gives (p. 123) the standard capacity of a lightning-conductor as that "the quantity of metal should not be less than that represented by the section of a solid cylinder half an inch in diameter;" the "conditions" would have been of greater practical avail to the unscientific, had he given an idea of the limits, beyond which this capacity should be increased, in less general terms than in the words "if the length be very considerable." The reader must supply this blank, by referring to the Report of the Committee of the House of Commons, on Mr. Harris's conductors, and examine the relative dimensions of the metal plates for the respective masts of ships.

Mr. Harris's "conditions" also include the (to us) very essential

Digitized by Google

element, thus expressed in his fourth deduction:—"The conductor should involve in its course the principal detached masses of metal in the building;" or, as he elsewhere expresses it, (p. 97) the lightning-rod "should be so applied, that a discharge of lightning falling on the general mass, could not possibly find its way to the ground by any circuit of which the conductor did not form a part; that is to say, the conductor should be united with all the great masses of metal in its vicinity, which offer other possible lines of discharge;" for, as he writes in another place (p. 106), "although the general tendency of a discharge of lightning is always through the conductor, as being the line of least resistance, yet there may arise cases, in which the electrical forces may be so circumstanced as to effect other lines of action near it, and in which damage may ensue." Indeed, as the "course is invariably determined through a given line or lines, which upon the whole oppose the least resistance to the neutralization of the electrical forces;" and as the "lightning seizes upon such bodies, as lie convenient and ready for its purpose, absolutely avoiding other bodies, however near, from which it can receive no assistance;" it behoves us to be especially careful to include in the system any bodies which circumstances might make ancillary stepping stones to the ultimate restoration of equilibrium. And on this point Mr. Harris's opinion and our own *now* * coincide.

The uninitiated in electrical phenomena will do well to study with attention § 44, and make himself master of, as Mr. Harris writes,—

"A most wonderful and interesting fact, that, at the instant before the explosion takes place, the stream of electricity, in the act of moving, to restore the equilibrium of distribution, feels its way as it were in advance, and absolutely marks out the course it is about to take, an inductive action being impressed upon such bodies as happen to lie in the line or lines of least resistance; this previous induction, by a sort of foresight, determining the course of the discharge. Its progress, therefore, is not, as many imagine, left to the chances of the instant, to be, as it were, attracted or drawn aside by metallic bodies at any given point; on the contrary, the whole course of a stroke of lightning is already fixed and settled, before the discharge takes place."

We have said this is a good text-book; but an attentive perusal will convince the reader that M. Arago was not wrong, when he said that the study of these phenomena was very far from being exhausted: he will see that there are some points, on which differences of opinion still prevail; and that these are not matters of vain speculation, but subjects of vital importance to the right understanding of the main question, namely, "the nature of thunderstorms."

Having been ourselves engaged in investigations, the results of which are in the possession of many of our readers, relative to the inferences to be drawn from a series of generally recognized facts; and having arrived at conclusions differing in some degree from

* Vide Proceed. Elec. Soc. p. 355 and 413.

Digitized by Google

those maintained by the respected author of the work before us, to whose consideration and courtesy we have been more than once indebted, we feel a degree of delicacy in treading again that arena, whereon we have been compelled to take an opposite station. Indeed, in our present position, we are not justified in doing more than to direct the attention of the intelligent electrician to certain truths, the bearings of which remain to be determined. Let him for instance, turn to page 14 of Mr. Harris's work, where he will read:—"There would be, according to the principle we have just supposed, an alternate electrical condensation and exhaustion brought into play, which, at last reaching the earth's surface, would there elicit an electrical force, N, *exactly equal* to the force at P [the cloud] but of an opposite or neutralizing quality; so that there would arise at N, by this kind of action, an electrical exhaustion or displacement, *just sufficient* to tranquillize the active accumulation at P." Now let him turn onward to page 195, and read,—"Now it is to be observed, that, in a charged electrical jar, the force on the charged side is from the *process of charging*, and *from the induction of surrounding bodies* necessarily *in excess* of the force developed in the opposite coating." Let him, then, cease the *process of charging*, and remove the Leyden jar, or glass plate rather, from the effect of *surrounding bodies*, to learn, as he will learn, that the *character* of the charge is still the same, viz. *in excess* on the one coating. Then let him read, in page 27, that "the *nature* of the insulating substance between the planes does not in any way interfere with the conditions of this arrangement, nor does its *thickness*;" and he will be at a loss to discover why the charge should be *equal* in the one case—that of the clouds, and *in excess* in the other—that of the Leyden plates; he will hesitate in granting that "it is very possible that the forces between these [the earth and the clouds] *may exactly* compensate each other without any remainder;" he will think they may *not exactly*; and he will be led to think, if not exactly, then how wide will the difference be? These and a few other facts, which bear on them, will teach him that there is much yet to be done before the matter will be set at rest: after having found an excess on one side of a charged plate of glass, whether other bodies be or be not near it, he will be slow to confess—"we have seen why it is that any excess remains, after the discharge of an electrical jar, simply *because other bodies share in the induction*," (p. 200). He would not be content to think, "there would be either *no excess* of electricity in the clouds after an atmospheric discharge, or otherwise, *if it existed*, it would remain there until, &c." (p. 200); he would resolve the *if*; for while that remains, he could himself possess no certain knowledge; he would feel himself in a state of pupillage, and endeavour—But we must refrain our pen; or we shall be involving our readers in the intricate but interesting questions connected with the lateral spark, the division of charge, the residual and the induced residual charges; and the many points emanating

Digitized by Google

from these. Inviting though the subjects are, we forbear, and return again to our author.

Mr. Harris's book abounds in the *why* and the *wherefore*; and is hence of much theoretical interest; it also dwells at some extent on the *how*, and is hence of great *practical* value. We must not close it without remarking that it is well furnished with wood-cuts, wherever they can be of avail; and has some excellent plates of St. Martin's and Brixton Church.* Nor can we terminate our notice without giving the following ingenious and very philosophical explanation of the so-called "fire-balls," which have been so much a stumbling block to philosophers, (p. 36):—

"A great deal has been said relative to these appearances, and some doubts have been entertained of their real existence as mere balls of electrical light. Nevertheless the evidence of a form of disruptive discharge, faithfully conveying to the observer such an impression, is beyond question. . . . . The great number of accounts of such appearances, and the remarkable coincidences in them all, extending as they do through nearly a whole century, and consequently given by observers in no way connected with each other, leave not the least doubt of their existence. . . . .

"It is by no means easy to explain these appearances on the principles applicable to the ordinary electric spark; the amazing rapidity with which this proceeds, and the momentary duration of the light, renders it almost a matter of impossibility that the discharge should appear under the form of a ball of fire; it would be a transient line of light: we must look therefore to some other source for an explanation of these appearances.

"Now it is not improbable, that in many cases in which distinct balls of fire of sensible duration have been perceived, the appearance has resulted from the species of brush or glow discharge already described, and which may often precede the main shock: the ball of fire, observed by M. Toscan at the Botanic Gardens, Paris, was evidently a result of this kind. In short it is not difficult to conceive that, before a discharge of the whole system takes place, that is to say, before the constrained condition of the dielectric particles of air, intermediate between the clouds and earth, becomes as it were overturned, the particles nearest one of the terminating planes, or other bodies situated on them, may begin to discharge on the succeeding particles, and make an effort to restore the neutral condition of the system by a gradual process. . . . .

"If, therefore, we conceive the discharging particles to have a progressive motion from any cause, then we shall immediately obtain such a result as that observed by Mr. Chalmers, on board the *Montague*, in which a large ball of blue fire was observed rolling on the surface of the water towards the ship from *to windward*. On nearing the ship, the point of discharge became transferred to the head of the mast, and the striking distance being thus diminished, the whole system returned to its normal state, that is to say, a disruptive discharge ensued between the sea and the clouds, producing the usual phenomena of thunder and lightning, termed by the observers, 'the rising of the ball through the mast of the ship.'"

A Manual of Electricity, Magnetism and Meteorology. By Dionysius Lardner, D.C.L., F.R.S. &c. &c. In two volumes; Vol. 1. London: Longman, Paternoster Row; John Taylor, Upper Gower Street, 1841. Small 8vo. pp. 440.

Although the "Electrical Magazine" is especially devoted to the advancing stages of the science, and must leave first principles far

* In the description of the latter, the printer has by mistake given the word *foot* instead of *yard*, p. 87, l. 9.—Ed.

Digitized by Google

in the rear, yet its pages cannot be closed against the writers of elementary treatises; for on them the obtaining of valuable recruits to the already crowded ranks greatly depends. And it is only in proportion as the teachers of a science are true to their vocation that a right foundation-stone is laid in the breast of their disciples. The author of a popular treatise on Electricity requires a clear head and a sound judgment; for there lies before him a mine so rich in its resources, that, unless thus qualified, he will not succeed in selecting what is best fitted for his use, and rejecting what can safely be omitted. When we remember that Becquérel's Treatise on Electricity fills eight goodly volumes, and that much has been added to the science since he wrote, we must not be hypercritical over the work of one who is confined within more moderate limits; and must regard such labours, even though extended over two volumes, as this will be, as but elementary treatises. We make these remarks, because each is apt to complain of the omission of a peculiar series of facts which he, had he been the author, would have included; forgetting that if his facts, and a host of others which he knows to be wanting, were included, the book would so grow beneath the pen, as to cease being what it professes to be.

The volume, which has occasioned these observations, is the 130th in the series of the *Cabinet Cyclopædia*, and has been in the hands of the public for two years; and we revert to it now, because the long-expected second volume is on the eve of being issued. The plan pursued has been to give first an historical notice of the progress of electrical discovery; and then to enter on the science itself. The former, which is the introductory portion, occupies upwards of 200 pages, and includes all that is worthy of note, from the first effects observed by Thales, to the researches of our own time. It is divided into Electro-Statics, Electro-Dynamics, Magnetism, Electro-Magnetism, and Thermo-Electricity. The second division applies to Voltaic Effects.

Then comes the commencement of the treatise on the first division, to be followed evidently by the others, in the order given. Dr. Lardner's position as a popular writer, has been already determined by the public; and it is not for us to give our vote in this, the eleventh hour, on a question which has long since been decided. The treatise, as far as we yet see it, contains more information than any other with which we are acquainted, and may be safely placed in the hands of the young electrician. We object greatly to the close adherence of the author to the two-fluid theory, for it involves much circumlocution, and occasionally throws a veil of mystery over the descriptions. It assists in the introduction of the doctor's favourite science, mathematics; but we doubt whether the elementary character of the treatise is magnified thereby. We shall again refer to this *Manual* when the second volume shall have appeared.

Digitized by Google

Supplément à la Bibliothèque Universelle de Genève. Archives de l'Electricité. Par M. DE LA RIVE, Professeur de Physique à l'Académie de Genève. Nos. 1. à 9. Juin 12, 1841, à Juillet 18, 1843. Paris, Anselin. London, Ballière.

WE take not the "Archives" in hand for the purpose of entering into a view of their contents, but rather to point them out to the notice of our readers as being an essential portion of every electrical library. The space devoted to matters of science in the pages of the Bibliothèque, was daily becoming more and more inadequate to its allotted purpose. The days of peace had encouraged so many labourers into its all-fertile fields, that the harvest began to demand increased provision for its reception; and as electricity was no less productive of abundant returns to those who cultivated it, than its sister sciences, a larger arrear of new facts would have accumulated, had not further provision been made. M. de la Rive very wisely undertook the publication of the "Archives," in which to treasure up these results; and for which the electrician owes him much. The book was first issued in quarterly numbers, and now appears every alternate month, the last number bearing the date of July 18th. Like our own "*Magazine*," it is entirely devoted to Electricity; it contains not only the daily additions to the science, but also reprints or translations of memoirs which are not generally known.

The pleasure with which we receive each consecutive number, connected with the value we place on a work professedly devoted to our own science, tend to make us very partial judges. But if all our readers love the science as we ourselves do, then are we full sure that the "Archives" will be a welcome and valued book to them. It is not sufficiently circulated in this country; it is not, indeed, sufficiently known. As a matter of duty, therefore, we take this early opportunity of reminding our readers of its existence, and giving it our best recommendation. It will save them the labour of searching for electrical papers in the contemporary periodicals, for all things of interest are gradually included in its pages; and it will liberate them from the fetters which a limited knowledge of languages entails, for they will find here translations from all sources. The position occupied by its author, and the practical knowledge he possesses of the many branches of physical science will ensure a careful selection from the extensive mass of materials now before him; and we are glad to see that, in making this selection, he extends the utility of his work, by very frequently giving in abstract the essence of certain memoirs, which, if given entire, would have encroached unnecessarily on his limited space. We are almost tempted to take a glance at the many memoirs included in the Nos. already published; but we fear being carried away by the interest of the subjects, to forget how limited our own space is; let it suffice, that every name of eminence in recent electrical discovery, is contained in "Les Archives."

Digitized by Google

NOTICES OF EXPERIMENTS.

Novel Application of the Gas and Water Pipes.—Mr. Bachhoffner has found by experiment, that the gas and water pipes may be made available as the positive metal of a voltaic pair,—the negative metal being a sheet of copper buried in the earth. The electricity thus obtained is of low tension, but produces a steady deflection of 60°. The same fact had two or three months previously presented itself to Mr. Bain, of which Mr. Bachhoffner was not aware.—*Mirror, July* 15 and 29, 1843. Mr. Gassiot also had produced electrolytic action by somewhat similar means: but he employed the metal pipes as the negative element. By means of a thin copper wire, a platinum electrode was connected with the gas-burner in his laboratory, a similar electrode was connected in like manner with a plate of zinc, a yard square, buried in the garden: the two electrodes were placed in a solution of sulphate of copper. At the time we witnessed the experiment, the action had endured for a day or two, and the electrode connected with the zinc was well coated with "reguline" copper.—[Ed.]

Printing Telegraph.—The *Gazette des Postes* of Frankfort, announces that an Englishman, named "Yardley," residing at Manheim, has invented a typo electro-magnetic telegraph, by which news may be transmitted with the greatest rapidity from one place to another, and which, at the same time, fixes the impression on paper, in the same manner as by a printing press and types.—*Mech. Mag. May* 27, 1843.

Electro-Lithotomy.—It is said that a patent is on the eve of being secured for the reduction of calculi, by means of electrolytic action. The nature of the process, and the character of the apparatus are not yet known. It is affirmed that instantaneous relief will be afforded; and calculi of the largest size can be brought away.—*Polytechnic Review*, Aug. 12, 1843. We believe that this is not altogether a new idea; but success does not seem to have attended any previous experiments.—[Ed.]

Magnetic Phenomena.—"The magnetic force may be communicated to a mass, composed of molecules of iron, independent of each other, and contained in a copper tube; and polarity may be given to it. The magnetic force is not sensibly augmented, when the said mass is condensed by compression. But that which proves how little the magnetic state is influenced by cohesion is, that these independent molecules may be mixed with a powdered substance, which is not sensibly susceptible of acquiring magnetic virtue; and that even five parts of powdered quartz for one of iron may be introduced, without destroying the magnetism of the mixture, which still preserves its polarity.

"It is readily seen that magnets, composed in this manner of independent molecules, can preserve their polarity only as long as the molecules, which compose them, preserve their respective situation. And, in fact, by vibrating the tube with sufficient force to change their relations, polarity is destroyed. . . . These facts

Digitized by Google

prove, as plainly as possible, that the extinction of the magnetic state depends on the change in the situation of the molecules, which neutralize each other by corresponding in the sides or poles endowed with opposite properties; they prove also that the magnetic force resides in the intimate molecules; for protoxide of iron, reduced to extremely fine powder, being employed in the same way as the filings, gives the same result."—Dr. DE HALDAT, *Ann. de Chim.* t. 42. *Arch. de l'Elect.* 18 July, 1843.

Electro-Plating.—The solution employed by Major Jewreinoff, especially for plating cast-iron, is made of excess of chloride of silver, dissolved in solution of the simple cyanuret of potassium: his object in using a superabundance of the chloride is, that he may avoid excess of the cyanide; for he finds free cyanide of potassium deteriorates the solution, and prevents its plating so well.—*Bull. de St. Petersbourg.*

Auro-Cyanide of Potassium.—Mr. A. Meillet describes this crystallized salt as far better for electro-gilding than the solutions generally employed. He procures it by adding pure cyanide of potassium to a saturated solution of perfectly neutral chloride of gold. On evaporation the salt crystallizes in very white scales of a pearly lustre.

Platino-Cyanide of Potassium.—This salt is prepared by the same chemist, by conveying concentrated chloride of platinum into a saturated solution of cyanide of potassium; a precipitate of chloride of potassium and platinum falls, mixed with the cyanide; on heating to boiling re-dissolution occurs, with copious disengagement of carbonate of ammonia. After the entire solution is accomplished, it is allowed to cool, and the platino-cyanide of potassium separates in blue acicular crystals, which are yellow by transmitted, iridescent purple by reflected light.

Argento-Cyanide of Potassium is obtained by dissolving to saturation cyanide of silver in cyanide of potassium, filtering and evaporating, when the salt crystallizes in square rectangular prisms.—*Chem. Gaz.*, Aug. 1, from *Arch. der Pharm.* for June.

*Coke for Negative Element.**—Major Jewreinoff has found by experience, that the best mixture for coke-cylinders should consist of five parts by weight of finely powdered coke, eight parts coal and two parts common rye flour. When the cylinders are dry, they are placed in earthen crucibles, in the lids of which there is an aperture for the escape of the gases, and are then heated to redness.—*Bull. de St. Petersbourg.*

Elkington's Patent.—" An action has been brought in France by the representatives of Mr. Elkington, the proprietor of a patent for the new process of gilding by immersion in a bath of gold and alkali, against MM. Simon, Redier, and others, for piracy; and a cross-action was brought by those parties, with a view of having it declared that Mr. Elkington's patent was null and void, on the ground of the process being public property. The case having come before the Cour Royale, on an appeal of one of the parties

* Vide Elec. Mag. No. I. p. 16.

Digitized by Google

from the Tribunal of Commerce, a series of experiments was ordered; and, on Saturday last, the Court, after a full and detailed report of the operations, and ocular demonstration of the process, gave judgment in favour of the representatives of Mr. Elkington, by declaring that, although the gold and alkali bath, as used by that gentleman, had long been known as a chemical discovery, he was the first person who had applied it to the gilding of metals, and therefore his patent was good. MM. Simon, Redier, and Co. were therefore declared to have no right to use the same process, and condemned to all the costs of the suit, which are said to amount to 40,000f."—*Athenæum, Aug. 19th.*

Lightning Conductor to the Nelson Column.—"When the conductor cannot be led through the centre of a column, it may be applied to its surface under the form of copper plates, varying from five to six inches in breadth, and one-fifth of an inch in thickness; these being fixed firmly to the masonry, may be covered with any sort of powdered stone, so as to assimilate its appearance with the building. It is proposed to apply a conductor of this kind to the Nelson monument, now erecting in Trafalgar Square, London. The plates of copper are three inches wide, and one-fifth of an inch thick, led in two lines along the adjacent fillets of the flutes of the column, and applied in lengths of ten feet, united by dove-tailing; by means of the new blow-pipe, the union may be made very perfect. The whole is pinned to the masonry by copper nails, secured with lead: thus the shaft itself has a metallic conductor of considerable capacity. The conducting plates are united to the ornamental bronze work surrounding the capital, which is again connected with bands of metal, traversing the back and sword of the figure, and ending in two points, one at the aigrette of the hat, the other at the extremity of the sword. At the pedestal, the two separate lines of metal unite with a plate six inches wide, carried on near the north-east angle to the earth, where it is connected with three pointed branches under the surface of the ground, thus fulfilling the requisite conditions for a perfect defence."—Harris *on the Nature of Thunder-Storms, &c.* p. 126; 1843.

Lightning.—The commander of the *Vigie* communicated to the French Academy, that in a recent voyage, his mainmast was thrice very severely struck with lightning, but that in consequence of its being provided with paratonnerres, no damage occurred to the vessel. A sailor, who was sent aloft to see what effect the lightning had produced, experienced such shocks every time he placed his hand on the base of the paratonnerre, as nearly threw him down. The conductor, as well as all the iron in the ship, became permanently magnetized;—the compasses were rendered useless, as was also a new compass, which was obtained several days after.—*Compte Rendu*, Aug. 7, 1843.

The extent of the Protecting Influence of a Lightning-rod.—In 1823, the Minister of War consulted the French Academy on the limits of the space protected by a lightning conductor; when they appear to have adopted the opinion of M. Charles, the grounds

Digitized by Google

for which are not evident, that a lightning conductor protects around itself, *a circular space of a radius equal to* DOUBLE *its height.*

Subsequent writers have very frequently adopted this opinion as an element in the description of these instruments; but many philosophers have been slow to admit it, among whom may be named Arago, Harris, Elice, &c. Cases are not wanting to sanction their views. Another instance has recently occurred:—On the first of June, last, a building in the Rue St. Jaques, near the Val-de Grace, furnished with a lightning-conductor, was injured by lightning. M. Arago pointed out to the French Academy,* that the damage occurred within the prescribed limits; and the Academy have appointed a commission to investigate the case fully.—ED.

M. de la Rive's New Work.—A treatise on electricity applied to the arts, to medicine, and physiology, by the Professor of Geneva, is in the press: we had hoped to see it before this number was out.—ED.

Palladium for Lightning rods.—Prof. Elice proposes palladium for the points of lightning-rods, on account of its superior conductibility, its difficulty of fusion, and its inalterability by the action of the air.—From MATTEUCCI's *Lezioni di Fisica*, t. 2. p. 288, he quotes Pouillet's table of the relative conductibility of metals, which, expressing the conductibility of mercury by 100, gives:

Palladium . . .	. 5791
Silver alloyed, 963	. . 5152
,, ,, 900	. . 4753
,, ,, 857	. . 4221
,, ,, 747	. . 3882
Gold pure . . .	. 3975
,, alloyed, 951	. . 1338
,, ,, 751	. . 714
Copper, pure . .	{ 3838 { 3842
Platinum . . .	. 855
Iron	{ 700 { 600

These data are the results of recent experiment.—*Nota. Observazioni sui Parafulmini.* Aug. 1st, 1843.

Majocchi's Electroscope.—In place of the two dry piles, employed in Bohnenberger's electroscope, Prof. Majocchi proposes the substitution of permanently charged Leyden phials, which idea originated from Canton's having retained a charged jar for a very considerable time. The vials are formed of a glass tube, closed at one end. The inner coating is mercury or shot. Having charged the inner surface in the usual way, the open end is hermetically sealed, or stopped with shell-lac. The permanency of the charge is found to depend greatly on the character of the glass, which ought to be free from potash.—*Annali di Fisica, &c.* April 1841.

Magnetic Pictures.—"Experiment having proved that the magnetic state may be developed in the centre of a plate of soft steel,

* Vide *Comptes Rendus*, June. 5, 1843.

Digitized by Google

and remain there without the neighbouring parts participating in the state of the central parts, we have been able, with a bar-magnet to trace magnetic figures analogous to the electrical figures of Lichtenberg, and to the acoustic figures of Chladni. Soft iron, but especially in the condition of steel, is very fit for these experiments, the process of which consists in moving the pole of a magnet over the surface of a plate, as is done in tracing figures with a pencil. These figures are more pure on steel than on iron, and are preserved longer. They are rendered evident, by projecting on the surface of these plates a small quantity of iron filings, or of the powdered protoxide of the same metal, and by communicating to the plate thus magnetized a few slight vibrations by shaking, which determines their arrangement. These figures may be traced, not only by the immediate contact of the magnetised bar, but even without this contact, by moving the magnet at a little distance from the surface of the plate of steel, by means of a rule, which keeps this distance equal, and which may be from 5 to 10 millimetres."—Dr. de Haldat.—*Annales de Chimie, &c.* t. 42.—*Les Archives de l'Electricité*, No. 9, July 18, 1843.

Lightning.—The *Courier du Bas Rhin* of Strasburg relates that, during a violent storm on the 10th inst., the lightning was attracted by the conductor of the cathedral, to which building it did no injury; but, on reaching the ground, instead of descending into the earth, went off at an angle, and entered the open door of the workshop of a tinman. In the shop, which is about 30 feet square, there were seven persons, through whom the first portion of the electric fluid was seen to pass, in the shape of a small ball of fire, along the ground, without touching any one of them, and then burst into a large and bright flame against an iron bar at the bottom. The conductor, on being examined, was found to be without any defect at the foot or elsewhere. The *Alsace*, another Strasbourg journal, attributes the above divergence of the lightning to the superior attraction of a large quantity of iron and lead that was in the workshop.—*Athenæum*, July 22, 1843.

Electro-etching.—" Dr. Pring has just described (*Phil. Mag.* Aug.) another mode of etching. A positive steel or other metal plate is connected with the positive end of a series of 4 or 5, a good coil of coated copper wire being interposed between the plate and the battery. The other wire, guarded by glass or other insulator, is held in the hand and employed as an etching-tool, when any device may be drawn. The magneto-electric machine will also furnish electricity for this mode. The plate may be reversed, and connected with the negative end to vary the experiment. Various wires may be used. No solution is employed."—*Elec. Manip.* part 2, p. 52, Aug. 1843.

Gymnotus Electricus.—Two specimens of the gymnotus have just reached this country alive. They are from Para; are young, being about 2½ feet in length. A third specimen died in the passage. They have been purchased by the proprietors of the Adelaide Gallery.

Digitized by Google

ELECTRICAL MAGAZINE.

JANUARY, 1844.

XXVII. *On the Oxy-hydrogen Battery.* By C. F. SCHŒNBEIN. Extract from a communication to the Royal Academy of Munich. From "Les Archives de l'Electricité," No. 7. April, 1843. Vol. III., p. 69.

(TRANSLATION.)

IN the December Number of the Philosophical Magazine for 1842, Mr. Grove describes, under the name of a *Gaseous Voltaic Battery*, a voltaic pile which cannot fail of exciting the attention of philosophers.

Having previously observed that, when two plates of platinum are placed in tubes containing oxygen and hydrogen, and are connected with the wire of a galvanometer, they have power to produce a deviation in the needle of this instrument, the English philosopher filled a certain number of tubes with diluted sulphuric acid, and introduced hydrogen into the upper part of some, and oxygen into the upper part of the others; then, taking care throughout to connect a hydrogen tube with an oxygen tube, by means of a platinum plate, Mr. Grove formed a battery, with fifty of these pairs, on the model of the voltaic battery; he thus obtained an apparatus, which gave rather strong discharges, produced sparks distinctly visible between two fine charcoal-points, and possessed a pretty considerable electrolytic power. When the tubes were filled with atmospheric air, instead of the above-named gases, and were connected into a battery, they gave no current; which was equally the case, when the tubes contained alternately, some carbonic acid and nitrogen or oxygen, others, nitrogen. Very feeble effects were obtained, when the successive tubes were alternately filled with hydrogen and nitrogen.

Mr. Grove, having advanced certain theoretical considera-

Digitized by Google

tions on the pile, which I have just described, and myself having, a few years ago, experimented on the voltaic power of oxygen, hydrogen, water, and platinum, the results of which are very intimately connected with the more recent observations of the English philosopher, and are even in perfect accordance with the latest,—these two circumstances have induced me to subject the new pile, as well as the cause of its action, to a somewhat more rigid examination; and I was the more willing to undertake this task, inasmuch as it is connected with certain scientific questions, which, in my opinion, possess some degree of importance.

In 1838, I discovered the fact that water, contained in a U tube, and through which the current of a battery has been passed, is not polarized or does not form an active pair except when the two columns of the liquid, contained in the two branches of the tube, are connected by means of platinum. More recently, I shewed that water, containing hydrogen in solution, and which is combined voltaically with pure water, produces a current, that passes from the former of these liquids toward the latter, which is not manifest unless the two liquids are connected by means of platinum, or, at least, when the part of the connecting metallic arc, which enters the solution of hydrogen, is formed of platinum.

I further demonstrated that a solution of oxygen in water, when combined voltaically with pure water, does not develope a current, and does not form an active pair, even when the circuit is completed with platinum. Thus, in conformity with my preceding experiments, a current is not developed except when hydrogen, water, and platinum, enter simultaneously into contact, and communicate, so as to form a circuit, which returns on itself, or a closed pair.

In a memoir, on the polarization of solid bodies and liquids, which I had the honour of presenting to the Academy last year, and which was afterwards published in *Poggendorff's Annals*, I collected all the results which I had obtained on this subject, and advanced certain conjectures as to the cause of the phenomena which I had observed; I therefore take the liberty of referring to it.

It clearly results from the Memoir, in which Mr. Grove describes his new battery, that the author attributes the development of the current to the combination of hydrogen and oxygen, a combination which, in his opinion, takes place under the catalytic influence of the platinum; but this supposition does not appear to me admissible, and for the following reasons:—

1. From my experiments, a current is obtained even when a

Digitized by Google

solution of hydrogen in water is voltaically combined with water which is pure and perfectly deprived of oxygen, and when the circuit of the battery thus formed is completed with platinum. In this apparatus, the chemical action, to which Mr. Grove attributes the current of his battery, cannot be entertained, because this battery contains no free oxygen. But it necessarily follows, from this fact, that one part at least of the current of the new battery, has another origin than that assigned to it by Grove.

2. If pure oxygen or atmospheric air is passed into the solution of hydrogen in my battery, the current, according to my observations, absolutely receives no increase; the contrary ought evidently to take place, if the immediate combination of oxygen with hydrogen produced as its result the development of a current.

3. The arrangement of the elements of Grove's new pile is of such a nature that it is difficult to conceive how the oxygen of one of the tubes can combine with the hydrogen of the other, seeing that the two gases are separated from each other by a thick layer of liquid. It is true that the communication between two consecutive tubes being established, by means of acidulated water, it may happen that a part of the oxygen in one of the tubes passes into the liquid of the tube containing the hydrogen, and reciprocally, that a part of the hydrogen passes into the oxygen tube, whence it follows that there would be oxygen in solution in the liquid of both tubes, and that the two gases would be in contact with the platinum plates plunged in the liquid. But, as the current shows itself as soon as the circuit is closed, that is, in an interval during which such a mixture of the gases cannot be admitted, it clearly follows that this current cannot originate from a direct combination of free oxygen with free hydrogen. Now the facts mentioned in the preceding paragraph show that the current of the battery would not receive any increase from the access of oxygen into the tube filled with hydrogen.

Supposing even that the mixture of the two gases could take place very speedily, and that the presence of oxygen in hydrogen does augment the force of the current, it is easy to comprehend that these very two circumstances might also soon put an end to the current of the pile, for, if the development of the current must really be attributed to the combination of hydrogen with oxygen, and if this chemical action take place not only in the tubes taken two and two, but in each of those which compose the pile, the currents, which would be due to these different actions, would in this case, of necessity, destroy each other, because they travel in contrary

Digitized by Google

directions. These reasonings, to which I might add others of no less weight, show, in my opinion, most conspicuously that the development of the current of Grove's new battery is not due to the direct combination of the oxygen employed in this apparatus with the hydrogen.

It now concerns us to learn what is the true source or chemical cause of the current in question. In the memoir on Voltaic Polarization, which I have mentioned, the reply to this question has been anticipated, that is, I have advanced an opinion, which is rendered probable by facts, that the immediate cause of the current of my hydrogen pile is the presence of a sub-oxide of hydrogen which is formed of the hydrogen and the water, under the catalytic influence of the platinum. Now, as the current of this battery has the same direction as that of the current of Grove's battery, and as the resemblance between these two apparatus, in so far as the substances employed in their construction are concerned, is recognised at a glance, I have not the least doubt that the current in both cases is due to precisely the same cause.

If we can admit with certainty that the source of the current under consideration is not due to the direct combination of oxygen with hydrogen, and if experiment shews that the presence of the former of these gases in the latter does not produce any augmentation in the intensity of the current; if, moreover, it follows from my previous researches that a solution of oxygen forming with pure water a voltaic pair, the circuit of which is closed by means of a platinum arc, does not develope any current, how comes it then that a battery, formed of tubes of oxygen, alternating with tubes of hydrogen, originates a more energetic current than that which is derived from an apparatus, in which tubes containing mere acidulated water are alternated with tubes of hydrogen? In other words, what part does oxygen play in Grove's new battery?

From the developments contained in my last memoir, relative to the electrolyzing effects of the simple battery,* I am compelled to trace the origin of the augmentation of the force of the current to a depolarizing action of the oxygen, in preference to any other cause. In fact, the action of the current, which flows from a tube filled with hydrogen to the neighbouring tube of oxygen, gives to the negative electrode, which is contained in the latter, a positive polarity by means of the hydrogen which is liberated on the surface of this electrode. But this positive polarity developes in its turn a

* *Poggend. Annal.*, No. 9, 1842, and *Archives de l'Electricité*, t. ii. page 241, 1842.

Digitized by Google

secondary current, which, inasmuch as its direction is concerned, is opposed to the primary current, and which must consequently weaken it. Now, if the negative electrode in question is surrounded by a liquid containing free oxygen, the hydrogen liberated on this electrode, produces, under the influence of the platinum, of which the latter is formed, a chemical combination with the neighbouring free oxygen, which also prevents the positive polarization of the negative platinum electrode, as well as that of the liquid surrounding it, and consequently opposes the weakening of the primary current.

The positive polarity, which the platinum acquires, as a negative electrode, being somewhat considerable, when compared with the force which developes it, it follows that the oxygen must produce a sensible augmentation in the force of the primary current of Grove's battery, in consequence of the depolarizing influence which it exercises in this apparatus. But it is possible, and even probable, that this same gas contributes also to augment the force of the current by the species of action, of which I have spoken in the memoir that I have already quoted.

If, then, Mr. Grove obtained but a feeble current, when he used, in his battery, nitrogen instead of oxygen, it is a result which can easily be understood; for the free nitrogen cannot, like oxygen, form, under the catalytic influence of the platinum, a chemical combination with the hydrogen liberated on this metal; nor can it prevent the positive polarization of the negative electrodes, nor, consequently, the feeble effects of the current arising from a battery of nitrogen and hydrogen.

The results of my previous researches on the polarizations of platinum, produced by the difficult species of gas, prevent our being in the least degree astonished that, according to the observations of Mr. Grove, batteries, formed of tubes, in which oxygen alternates with nitrogen, or carbonic acid with oxygen, do not develope any current. From these results, the gases indicated above exercise absolutely no sensible depolarizing influence on platinum in its natural condition, much more they cannot destroy the polarities developed in a metal, by certain gaseous substances, such as chlorine or hydrogen. Or, which amounts to the same thing, an aqueous solution of nitrogen associated with an aqueous solution of oxygen, and connected with it by means of a platinum arc, does not constitute an active battery; because the platinum does not exercise any catalytic influence over such solutions, or does not determine any species of chemical actions.

Digitized by Google

I think it is to the point to give here some notice of a battery, which might be named the hydrogen and chlorine battery, because hydrogen and chlorine play an important part as electro-motors. With this view, I may be permitted to mention a battery, which I constructed and described several years ago. An aqueous solution of chlorine, voltaically combined with pure water, developes a current, when the two liquids are united by means of any metals so as to form a battery; and this current is determined from the pure water to the solution of chlorine. A fact, precisely analogous to this, is the observation that a plate of platinum, when plunged into chlorine gas, acquires negative polarity, or that the same plate, plunged into water with an ordinary platinum plate, forms a pair, in which the current is determined from the ordinary platinum to that which has been in contact with the chlorine.

Now, if a certain number of pairs of this kind were connected together, a chlorine battery would be obtained, the elements of which would be an aqueous solution of chlorine and pure water. It necessarily follows that the energy of this compound battery would acquire very considerable increase, when the solution of chlorine as well as the water, contains a certain quantity of acid; for example, sulphuric acid. But, from what has been said above, the force of the current of this battery ought to increase to a still greater extent, if hydrogen gas were introduced into the cells, which contained only the solution of sulphuric acid; and that thus an acidulated solution of chlorine and an acidulated solution of hydrogen might be alternated in the battery, so that the chlorine cell should in all cases communicate, by means of platinum, with the neighbouring hydrogen cell. In a battery thus constructed, there is an electromotive action, not only in the chlorine cell, but also in the hydrogen cell, and these two actions develope currents, which have the same direction, and naturally assist each other.

It is not difficult to comprehend that, all other circumstances being similar, the force of the current of a battery of this kind must be much superior to that of the current of Grove's new battery; for, in the latter, there is no other electromotive action than that in the hydrogen tubes, whilst in the other tubes the oxygen plays solely or principally the part of a depolarizing substance.

With regard to the depolarizing influence which the chlorine exercises over the negative platinum electrodes of the hydrogen and chlorine battery, it is readily seen that it is superior to that which oxygen exercises over the same elec-

Digitized by Google

trodes, in Grove's new battery. Chlorine combines with hydrogen much more easily than does oxygen; so that the depolarization of the platinum electrodes must be brought about, by means of the chlorine, in more rapid and complete manner than by oxygen; and this can scarcely fail increasing the amount [*grandeur* Fr.] of current from the hydrogen and chlorine battery.

On studying a little more closely this last kind of battery in respect to the depolarizing actions which take place in it, we find that it presents one circumstance, which does not belong to any battery hitherto known. In fact, the chlorine and the hydrogen play two parts at once. First, in consequence of their particular chemical relations to water, these substances exercise an electromotive action, and develope, in the battery, currents the direction of which is, as we have already mentioned, similar; then, they destroy the polarities, which are developed on the electrodes of the battery by the action of the currents just mentioned. The positive electrodes are surrounded by the solution of hydrogen, the negative electrodes by the solution of chlorine; in consequence of the chemical action exercised by the current of the battery, ozone is developed on the positive electrodes, or else there is formed on these electrodes an oxide of hydrogen of a higher degree; whilst hydrogen is liberated, or a sub-oxide of hydrogen is produced, on the negative electrodes. By the action of the ozone or of the superior degree of the oxidation of the hydrogen, the positive electrodes acquire negative polarity; by the action of the hydrogen, or of the sub-oxide of hydrogen, the negative electrodes acquire positive polarity. Now, the hydrogen, which, in a state of solution, surrounds the positive electrodes, combines with the ozone liberated on these electrodes, or with a portion of the oxygen contained in the peroxide of hydrogen, which I have mentioned; the chlorine, which, in like manner, in a state of solution, invests the negative electrodes, combines with the hydrogen liberated on these electrodes, or with a part of this same gas, which is found in the sub-oxide of hydrogen, the existence of which I have supposed.

A battery may be constructed, precisely analogous to the hydrogen and chlorine battery, with a solution of hydrogen and metallic oxides; and my experiments have taught me that the peroxide of lead or of silver is particularly suited to this purpose. The peroxides, or rather the second proportion of oxygen, which they contain, act in every respect in an apparatus of this kind, as chlorine does in the hydrogen and chlorine battery: they are, at the same time, electro-motors

Digitized by Google

and depolarizers. Hence, if oxygen, in the gaseous state in Grove's new battery, is replaced by peroxide of lead, a battery is obtained, which, under equal circumstances, gives a stronger current than that which is developed by an oxy-hydrogen battery.

It is scarcely necessary to remark that the batteries, of which I have just spoken, can neither be recommended on account of their economy, nor of their energy. Nevertheless, in a theoretical point of view, they possess a great degree of interest, inasmuch as they shew, with the greatest distinctness, the intimate relation by which the chemical properties of bodies and their electro-motive state, that is, chemical action and voltaic phenomena, are connected. But the battery or series of hydrogen, water and platinum, appears to me very specially to deserve the attention of philosophers, for the reasons I am about to advance. Among all known metals, platinum is the only one, as appears from the researches I have made, which possesses the power of developing a current, by its contact with hydrogen and water; and, as it is the same metal which also possesses particular relations to oxygen and hydrogen, that is to say, which, in its contact with these two gases, developes in an extraordinary manner, their chemical affinities, it is really a difficult matter to refrain from attributing these different modes of the action of platinum to the same cause, namely, to that unknown force, to which Berzelius gave the name *catalytic*. Now, if these two modes of action proceed from the same cause, a fact of this kind ought to possess a high degree of scientific interest, because it might furnish the proof that the catalytic power, as well as ordinary chemical affinity, might, under given circumstances, produce voltaic phenomena, or act as electro-motive force.

But, if once we discover with certainty a single case, in which chemical modification, produced in a substance by catalytic action, is accompanied by the development of a current, we may expect that this case will not remain isolated, and that we shall eventually succeed, not only in discovering other similar cases, but also in throwing some light on the at present obscure relation which exists between catalytic force, and ordinary chemical affinity. Now, it is easy to see how important the exact determination of this relation would be to the theoretical part of chemistry, and how bright a light would be thrown on an entire class of phenomena, as soon as the nature of the chemical actions of contact should be known.

We could not then, in the whole field of physico-chemical

Digitized by Google

labours, select one which would offer more interesting points, or which would promise more important results than that which I have just pointed out. So that I am encouraged to hope, that, ere long, active researches will be made in this field, which will assure great conquests to science.

But there is still one other point of view, under which the power that the catalytic force might possess of developing voltaic currents, may offer some degree of interest. It is well known that philosophers are not wanting in Germany, who still faithfully believe, with Volta, that the principal source of hydro-electric currents lies in the contact of heterogeneous bodies, and who consider the chemical modifications, which occur in the battery, as nothing more than secondary actions, or as the effects of currents due to simple contact. Now, notwithstanding the great number of facts, which the partizans of the chemical theory of galvanism have endeavoured to advance in order to prove its correctness, not one has been regarded by its adversaries as possessing the force of conviction, not even those which Faraday made known in his last paper,* and which many philosophers have considered decisive. In like manner the partisans of the contact hypothesis, from time to time, advance facts and experiments which, in their opinion, ought to demonstrate unanswerably the incorrectness of the chemical theory, and to serve as *experimenta crucis* in favour of their opinion. Not one of these experiments has as yet been generally recognised as conclusive; so that the debate upon the source of voltaic electricity has not yet terminated.

Although, so far as I am myself concerned, I have not the slightest doubt that chemical action and the development of the current are associated in the relation of cause to effect; and although I think that there exists a sufficient number of facts, by means of which every unprejudiced man may form a conviction relative to the debate in question, it would be desirable, for the sake of science, that a phenomenon should present itself, the nature of which would leave so little material for doubt, that only one conclusion respecting its cause could be drawn. A phenomenon of this kind we may hope to find in the currents which are, in certain cases, developed by the catalytic power of a body.

If, for example, two conducting liquids were voltaically combined, and it were demonstrated that a battery of this kind has no action, when the circuit is closed with a conducting body, which would not exercise on one or other of the two liquids, either an ordinary chemical action, or a

* Exp. Researches, Series 16.—Ed.

Digitized by Google

catalytic action ; if, moreover, this same battery produced a current when the circuit is closed with a conducting substance which produces by catalysis, in one of the two liquids, a chemical modification of a synthetic or analytic nature, ought we not to conclude, from such facts, that the current obtained under these circumstances, would have its origin in the chemical modification which would have occurred? So far as I am able to judge, this conclusion would not only be admissible, but by far the most natural and the most simple which could be made.

Some time ago, I shewed that we possess in pure water and in an aqueous solution of hydrogen, two liquids of the character of those of which I have just spoken, and that we may with their aid construct the battery in question. This battery, when connected with gold, silver, copper, &c., does not produce any current; but a current is obtained, when, in order to complete the circuit, a metal is employed, which acts in so extraordinary a catalytic manner on oxygen and hydrogen, or on oxygen and certain hydrated combinations (for example alchohol and ether), that is to say, platinum.

Ought not the current obtained with this metal and the hydrogen battery, which I have mentioned, to be regarded as an *experimentum crucis* in favour of the chemical theory of galvanism? I abandon to impartial and competent philosophers, the decision of this question.—[A.]

Bâle, January 1843.

XXVIII. *Experiments made with one hundred pairs of Grove's Battery, passing through one hundred and sixty miles of insulated wire*; in a letter from Prof. S. F. B. Morse, to the Editors, dated New York, Sept. 4th, 1843. From Silliman's American Journal, Vol. 45, No. 2.—Oct. 1843.

Dear Sirs,—On the 8th of August, having completed my preparations of 160 miles of copper wire, for the electromagnetic telegraph, which I am constructing for the government, I invited several scientific friends to witness some experiments in verification of the law of Lenz, of the action of galvanic electricity through wires of great lengths.

I put in action a cut battery of one hundred pairs, which I had constructed, based on the excellent plan of Professor Grove, but with some modifications of my own, economising the platinum.

The wire was reeled upon eighty reels, containing two miles upon each reel, so that any length, from 2 to 160 miles, could be made at pleasure to constitute the circuit.

Digitized by Google

My first trial of the battery was through the entire length of 160 miles, making of course a circuit of 80 miles, and the magnetism induced in my electro-magnet, which formed a part of the circuit, was sufficient to move, with great strength, my telegraphic lever. Even forty-eight cups produced action in the lever, but not so promptly or surely.

We then commenced a series of experiments upon decomposition at various distances. The battery alone, (100 pairs,) gave in the measuring gauge, in one minute, 5·2 inches of gas. When four miles of wire were interposed, the result was 1·2 inches; ten miles of wire, ·57 inch.; twenty miles, ·3 inch.; fifty miles, ·094 inch.

The results obtained from a battery of 100 pairs are projected in the following curve :—

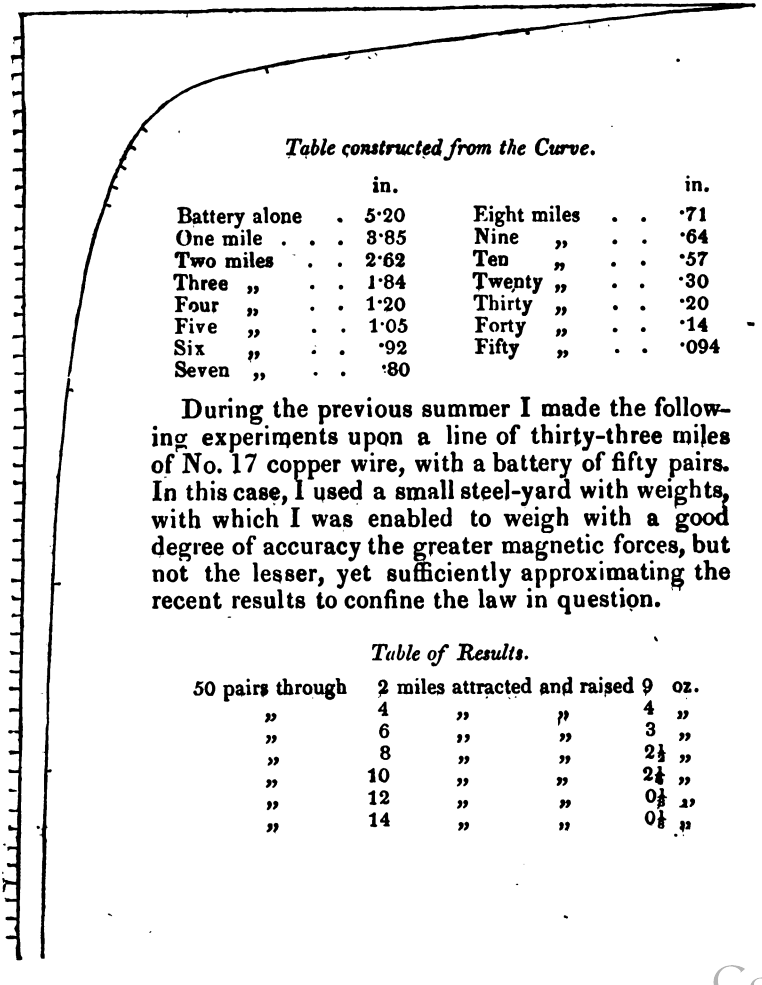


Table constructed from the Curve.

	in.		in.
Battery alone .	5·20	Eight miles . .	·71
One mile . . .	3·85	Nine „ . .	·64
Two miles . .	2·62	Ten „ . .	·57
Three „ . .	1·84	Twenty „ . .	·30
Four „ . .	1·20	Thirty „ . .	·20
Five „ . .	1·05	Forty „ . .	·14
Six „ . .	·92	Fifty „ . .	·094
Seven „ . .	·80		

During the previous summer I made the following experiments upon a line of thirty-three miles of No. 17 copper wire, with a battery of fifty pairs. In this case, I used a small steel-yard with weights, with which I was enabled to weigh with a good degree of accuracy the greater magnetic forces, but not the lesser, yet sufficiently approximating the recent results to confine the law in question.

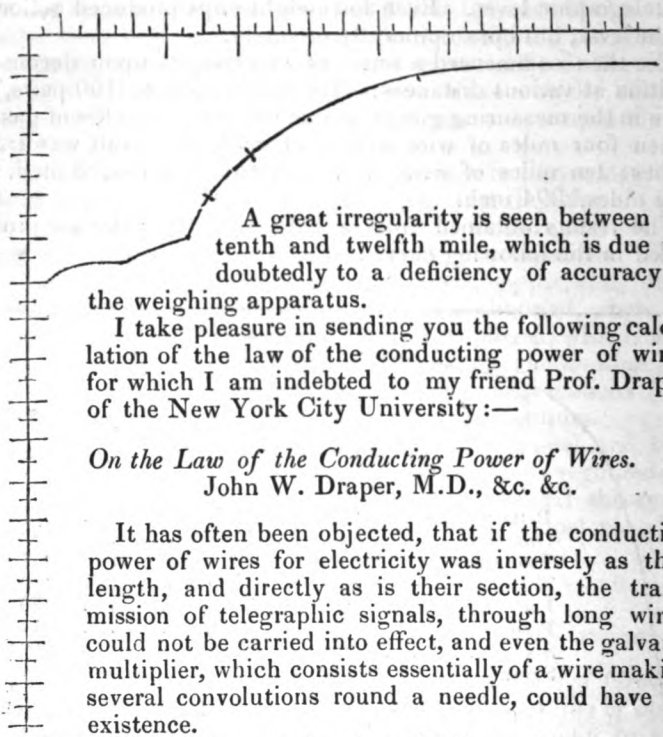
Table of Results.

50 pairs through	2 miles	attracted and raised	9 oz.
„	4	„ „	4 „
„	6	„ „	3 „
„	8	„ „	2½ „
„	10	„ „	2⅛ „
„	12	„ „	0½ „
„	14	„ „	0⅛ „

Digitized by Google

and each successive addition of two miles up to thirty-three, still gave an attractive and lifting power of $\frac{1}{8}$ oz.

Curve from the Results.



A great irregularity is seen between the tenth and twelfth mile, which is due undoubtedly to a deficiency of accuracy in the weighing apparatus.

I take pleasure in sending you the following calculation of the law of the conducting power of wires, for which I am indebted to my friend Prof. Draper, of the New York City University:—

On the Law of the Conducting Power of Wires. By John W. Draper, M.D., &c. &c.

It has often been objected, that if the conducting power of wires for electricity was inversely as their length, and directly as is their section, the transmission of telegraphic signals, through long wires, could not be carried into effect, and even the galvanic multiplier, which consists essentially of a wire making several convolutions round a needle, could have no existence.

This last objection was first brought forward by Professor Ritchie, of the University of London, as an absolute proof that the law referred to is incorrect. There is, however, an exceedingly simple method of proving that signals may be dispatched through very long wires, and that the galvanic multiplier, so far from controverting the law in question, depends for its very existence upon it.

Assuming the truth of the law of Lenz, the *quantities* of electricity which can be urged, by a constant electro-motoric source, through a series of wires, the lengths of which constitute an arithmetical ratio, will always be in a geometrical ratio. Now the curve, whose ordinates and abscissas bear this relation to each other is the logarithmic curve, whose equator is $a^y = x$.

1st. If we suppose the base of the system, which the curve

Digitized by Google

under discussion represents, be greater than unity, the values of y taken between $x=0$ and $x=1$, must be all negative.

2nd. By taking $y=0$ we find that the curve will intersect the axis of the x's at a distance from the origin equal to unity.

3rd. By taking $x=0$ we find y to be infinite and negative.

Now these are the properties of the logarithmic curve, which furnish an explanation of the case in hand. Assuming that the x's represent the quantities of electricity, and the y's the lengths of the wires, we perceive at once that those parts of the curve, which we have to consider, lie wholly in the fourth quadrant, where the abscissas are positive and the ordinates negative.

When, therefore, the battery current passes without the intervention of any obstructing wire, its value is equal to unity.

But, as successive lengths of wire are continually added, the quantities of electricity passing undergo a diminution, at first rapid, and then more and more slow. And it is not until the wire becomes infinitely long that it ceases to conduct at all; for the ordinate y, when $x = 0$, is an asymptote to the curve.

In point of practice, therefore, when a certain limit is reached, the diminution of the forces becomes *very small*, whilst the increase in the lengths of the wire is vastly great. It is, therefore, possible to conceive a wire to be a million times as long as another, and yet the two shall transmit quantities of electricity not perceptibly different, when measured by a delicate galvanometer.

But, under these circumstances, if the long wire be coiled so as to act as a multiplier, its influence on the needle will be inexpressibly greater than the one so much shorter than it.

Further, from this we gather that, for telegraphic despatches, with a battery of given electro-motoric power, when a certain distance is reached, the diminution of effect for an increased distance becomes inappreciable.

XXIX. *Note on the Flashes of Lightning which struck Strasburg Cathedral, on Monday, July 10th,* 1843, *at half-past* 1 P. M. By M. A. FARGEAUD. From "Les Comptes Rendus," August 7, 1843. Deuxième Semestre, No. 6, p. 254.

(TRANSLATION.)

SCARCELY was Franklin's invention known in Europe, when

Digitized by Google

the idea occurred at Strasburg, of protecting the Cathedral with a lightning conductor. It was not, however, until 1780, that a definite proposition was made to the magistrates of the city by Barbier de Tinan, commissary of war. His project, which had been submitted to the examination of Franklin himself, was approved of, in all its details, by the Academy of Sciences. But this proposition was not followed out; the learned naturalist Herman tells us that the too great expense was feared.

Forty-seven years afterwards, Professor Meunier recalled the attention of the authorities and the learned men of Strasburg, to this subject; in his memoir, he reverted to the visit which M. Gay-Lussac had just paid to the Cathedral, and the wish which the illustrious Academician had expressed, eventually to see this monument protected from the effects of lightning by a properly arranged conductor. An inconceivable opposition had just prevented the erection of a lightning conductor on the theatre; the demand of M. Meunier was therefore ineffectual.

Such was the state of things when, on the 14th of August, 1833, about 4 P. M., a most violent storm burst over the city; the tower was struck three times within a single quarter of an hour; the third stroke illuminated almost the whole of the building for a few moments: the lead, the copper, the iron, the mortar, the very pavement itself, were burned or melted in several places; the hammers were soldered to several bells, and were not detached without considerable difficulty. The repairs, which this terrible explosion had rendered necessary, cost several thousand francs. Serious accidents might have attended the fall of the fragments of stone, which were driven even into the neighbouring streets. Destruction like this, and the fear, which was its natural consequence, were more than sufficient to rouse anew the solicitude of the administration. A commission was named by the mayor, Frederick of Turckeim, to settle these three leading questions:—

1st. Is it right [*convenable* Fr.] to place a lightning conductor on the tower of the Cathedral?

2nd. What particular arrangements should be adopted in adjusting it?

3rd. What will be the expense?

This commission, which was organized two months after the event, was composed of MM. Lacombe, Husson, Voltz, Meunier, Herrenschneider, Fargeaud, and the architects, Spindler and Fries; it was proved, by documents, which were laid before them, that, for thirty years, the mean expense for repairing the damage by lightning, was 1000 francs (forty-

Digitized by Google

two guineas) per annum. But in the period preceding this, the existence of one part of the monument had been several times threatened. In 1759, for example, on the 27th of July, a lightning-flash burned all the wood-work of the roof of the church; the same year, in the month of October, the lightning struck the upper part of the tower three times during the same storm, and almost entirely destroyed one of the pillars of the lanthorn, &c.

I was instructed by my colleagues to draw out a summary of our discussions; my report was signed, and was addressed to the mayor, December 11th, 1833; the administration caused it to be printed; but they did not carry into effect the propositions which were laid down in it. Probably things would have once more remained in this condition, had not an explosion, more terrible even than that which we have just described, occurred on the 19th of July in the following summer, most opportunely to call us to order. One of the four turrets was cut, as it were, through the middle; enormous stones were displaced; numerous fragments were transported to considerable distances; it was very evident that we ought to set to work, and so at last we did.

Our colleagues, to whom M. Diebold was joined, were desirous that M. Fries the architect, and myself, should undertake the details of the operation. Some modifications of the original project were easily adopted, and the apparatus was ready for action by the summer of 1835. The following is a brief description of it:—

The cathedral, as a whole, is protected by three vertical rods, placed on the summit of the pyramid, on the guard-house, which occupies one end of the platform, and finally, above the choir, beside the telegraph. The conductors, which proceed from the base of these apparatus, communicate with the earth by three wells, about 10 metres (11 yards) deep.

One of these wells was dug at the very foot of the nave and the tower, beside the *Place du Château*, at the bottom of the passage, which separates the walls of the temple from the shops, that hide the lower part. The shop, which is nearest to this first well, is that of M. Rhein the tinman.

The second well is placed symmetrically, on the opposite side, towards the *Place du Dôme;* the third is behind the choir, also on the side of the *Place du Dôme*, and near the vestry, distant, therefore, from the other two by almost the whole length of the building. The three wells are also isolated from the public way; and each contains about 1 metre (a yard +) of water in the most unfavourable weather.

The conductor that protects the telegraph, is composed of

Digitized by Google

a brass rope, which, after being bent in various ways, arrives near the mouth of the vestry-well. This rope is then continued by a stout copper bar, terminating, at the bottom of the well, in the shape of a goose's foot.

The conical rod which surmounts the apex of the pyramid, and which constitutes the principal conductor, is at least 1 m. 50 c. (5 ft.) high. It seemed to me useless to elongate this rod for no other purpose than to attain or exceed the height of the highest pyramid of Egypt, as some amateurs ardently desired. The essential point was to fix it firmly on the narrow space from the middle of which it was to be elevated: its base was 5 or 6 centimètres (2 to 2¼ in.) thick. From this point proceeded four conductors formed of rectangular bars of iron, about 55 millimètres (2 in.) wide, and 15 (½ in.) thick. These conductors pass between the four arms of the cross, and bend according to circumstances, in order to follow the form of the crown of the lanthorn, and to arrive at the summit of the eight spiral staircases; they then descend in the intervals which correspond to the four turrets; on arriving at the upper level of the edifice, they are united by a circle which goes entirely round it, and are completely associated one with the other.

From this metallic girdle, it was thought sufficient to carry two conductors down the length of the turrets, on the north and on the east, that is to say, on the right and on the left of the immense copper roof of the nave, towards which the lightning is always directed. One of these conductors—that on the north turret—descends, almost in a direct line, from the summit of the pyramid to the well of the *Place du Dôme*, where it terminates by a bar of copper, the thickness and width of which correspond with those of the iron bars.

The second conductor descends on the side of the east turret, touches the corner of the ridge of the nave, and is bent in order to reach the well of the *Place du Château*, behind the tinman's shop. By an excess of caution, we thought we had better protect the guard-house, on the platform, by a separate lightning rod, the conductor of which is connected, at the mouth of the well, with the conductor that descends from the east turret.

The conductor of the tower, and those of the telegraph, are united by a long bar of iron, which follows the whole length of the ridge of the nave. All the other large metallic surfaces are also connected together, and with the general system of these conductors. The expense of the erection amounted to about 15,000 francs (£625), not including, I

Digitized by Google

believe, the three wells, which were constructed by the workmen attached to the monument.

During the last seven years, it does not appear that any flash of lightning, properly so called, has struck either the building or the conductors. It almost seems that storms had become less frequent and less intense over Strasburg: but on Monday, July 10th, 1843, a very violent storm burst over the town, and the lightning twice struck the cathedral, or rather the conductor.

Some individuals pretend to have seen a globe of fire enveloping the upper conductors of the lightning-rod, and gliding rapidly along their surface; but the man employed at the telegraph, who was better placed than any one else at that moment, assures us that he could only distinguish a luminous train rushing along the conductors from the top of the pyramid to the platform, where the conductor became invisible to him.

At the same moment, some remarkable phenomena occurred in M. Rhein, the tinman's shop, the position of which I have mentioned above. Seven or eight persons were assembled there: a considerable number of tin and zinc vessels were ranged on the sides; long bars of iron were resting, in an upright position, against the wall, in the corner which was nearest to one of the conductors. At the moment of the explosion, *they thought they saw* the lightning enter by the door, which opens on the *Place*, pass between the legs of the persons who were present, without, however, wounding any one, and burst in a great flame against the bars of iron, going thus directly towards one of the wells. This explosion was accompanied with a noise similar to that which would be produced on striking one of the bars with a great hammer. A minute after this first explosion, another thunder-stroke occurred; the electric matter again entered the same shop; but this time they were not aware of the direction in which it came.

Some workmen of the cathedral were, at the same moment, very near the shed which shelters the mouth of the well. One of them, of an advanced age, accustomed, so to speak, to this kind of observation, distinctly observed, on the pavement of the little yard behind M. Rhein's workshop, luminous trains, similar to those which he often remembers to have seen passing along the walls of the tower. Although he was very near, he did not feel any shock; he could distinguish neither their direction nor their form.

This, then, is the phenomenon which produced so lively an emotion in the neighbourhood of the cathedral.

Digitized by Google

What could be the cause of this deviation, partial no doubt, but, however, in some degree contrary to laws?

In the evening, after the storm, and especially on the following day, workmen descended in our presence into all the wells. M. Klotz, the architect, and M. Wagner, a clever locksmith, who constructed the lightning-rod, examined all the conductors from below upward to the summit of the pyramid, even to the apex. I did not feel myself called upon to follow these gentlemen to the limits of their aërial peregrination; but I went high enough to be convinced with them that all the conductors were sound at the points of junction, as well as elsewhere. It was impossible to discover along their whole extent the least trace of the passage of the lightning. So far as the monument is concerned, it was not touched,—not a single piece of stone or mortar was detached.

However, the electric matter evidently arrived by the summit of the apparatus, and the quantity must have been very great. In fact, the platinum cone, which was 8 centimètre (3 in.) long, and about 1 ($\frac{2}{5}$ in.) thick at its base, was melted towards the point, to a length of 5 or six millimètres ($\frac{1}{4}$ in.). The metal sank down on one side and ran like wax which had been softened at the fire. The part thus rounded presented, on the first day, the appearance of a small and very brilliant convex mirror. This point, together with the portion of the copper rod which supported it, has been taken down, and it will be preserved in the archives of the cathedral.*

My colleague, M. Finck, professor of mathematics, warned by the first explosion, immediately looked towards the summit of the tower. He saw the second flash of lightning arrive *horizontally*, in order to reach the point of the lightning-rod. The zigzags of this luminous line were not very distinct, and its length appeared to him about 50 mètres (55 yards). The cathedral was quite separate from the clouds; no light was observed either on the conductors, or on the body of the rod, the point of which had just received the fluid in so evident a manner.

Thus, then, the electric fluid struck the lightning-rod at its extremity, certainly in the second explosion, very probably in the first, which was much more powerful. Having arrived there, it had two paths to pursue, in order to reach the earth; one would have conducted it, almost in a straight line, into the first well of the *Place du Dôme*, with or without luminous

* They were sent for the inspection of the Members of the Academy.

Digitized by Google

appearances; the second path, longer, but quite as continuous, would have led it on the opposite side into the well of the *Place du Château.* In fact, on this side it is that a considerable number of persons profess to have seen brushes of light upon the conductors. There it is that the extraordinary deviation, which I have pointed out, took place.

A particular circumstance seems to us readily to explain the choice of the conductor, if, indeed, there was no division, and especially the deviation. Behind the workshop of the tinman, on the same side as the two conductors, which unite at the mouth of the well, was collected a large quantity of lead and iron, weighing about 2000 kilogrammes (2 tons), taken from the small roofs of the nave, which, at the present time, were being covered with copper. These pieces of metal were heaped one against the other, like a pile of wood, and presented an apparent volume of about 2 cubic metres (6½ cubic feet).

Very probably some of the sheets of lead touched the conductor; but it was impossible for us to verify this fact. On our arrival, the workmen had already removed a considerable portion in order to clear the mouth of the well. Admitting the contact, we see that this great surface of extraneous metal had the power of drawing off a portion of the current from its principal direction, and directing it toward the most vicinal exterior conductors. The masses of tin, zinc, or iron, which crowded the workshop and the loft above, certainly favoured this deviation.

If contact did not take place, we must suppose that, at the moment before the explosion, all the conductors vicinal to the lightning-rod, but not connected with it, were electrized by induction. When the explosion took place, a true return shock must have been produced in a locality prepared, so to speak, in the best possible manner for a phenomenon of this kind. Further, while attaching some degree of importance to the direction of the fluid, we need not trouble ourselves about the direction in which some persons say they saw it travel; we know how very easy it is to be deceived in this point.

If, in reference to certain electric sparks, I have been induced to enter into lengthened detail, it is, first, because it seems to me that we have yet much to learn respecting thunder; it is also to show that the lightning-rod acted with success, and that the only members of the Commission yet alive, M. Fries and myself, have not to reproach ourselves with negligence in the arrangement of the different parts of the protecting apparatus. I am very desirous that M. Arago,

Digitized by Google

who has rendered so much service to electro-meteorology, should take some interest in this long recital.

In conclusion, I may add, that on the following day, at about the same hour, another storm burst over Strasburg. The lightning struck the School of Pharmacy: it first attacked a bar of iron which traverses the upper part of the chimney; it then glided along the roofing, apparently to arrive at one of the gutters, by means of which the fluid was dissipated into the earth. This flash presented nothing remarkable, except, perhaps, the preference given to this building over those of the Academy, which are very near to it, which are much higher, and which are even furnished with a very small lightning-conductor.—[A.]

XXX. *Memoir on the Discolouration, by means of Electricity, of Papers sensitive to Light, and on a new class of Electric Pictures, or Electrographs.* By M. Aug. Pinaud. From "Les Comptes Rendus," 9th October, 1843. Deuxième Semestre, No. 15, p. 761.

(TRANSLATION.)

The object of this inquiry is to study the action of static-electricity on the chloride, the iodide, and the bromide of silver, and to compare it with that of light on the same substances.

I at first employed Daguerréotype plates, iodized or bromized. On throwing electricity on to one of these plates, from a point, whether it were positive or negative, I obtained, in a very few moments, brilliant spots of the bluish colour of steel, which were tinted at the edges. By this means, all sorts of figures or sketches can be traced. The discharge of a Leyden jar instantly forms circular spots of perfect regularity, presenting a very great analogy to those which Priestley obtained by means of powerful batteries on metallic surfaces merely polished.

Each of these modes of experiment was inefficient for the object I had proposed; for, independently of Priestley's experiment, M. Matteucci had recently shown* that a series of sparks, falling on the silvered surface of a Daguerréotype plate, *eventually* produces a bluish tinted spot. It is true that the electricity acts on the silver much more promptly, when the surface of the metals has been previously iodized; but this distinction may be regarded as illusory.

* Vide Notice in the present number of Elec. Mag.

Digitized by Google

I have, in fact, proved, that the action of very little sparks on a silver plate is *instantaeous;* and that the spots which they form, although they be not immediately visible, do nevertheless exist from the very first moment. In order to alter the metallic surface, there is no need to prolong the current of sparks, as M. Matteucci did; an instantaneous escape of electricity, without visibly affecting the metal, developes on its surface a deep and lasting alteration, which is rendered evident, as soon as a moist puff of breath has been directed upon the plate. The vapour condenses around the part which has received the electricity, and tarnishes the metallic surface; but the points, which have been acted on by the electric fluid, remain brilliant, and seem moistened by a transparent film of water. These points, therefore, possess the property of condensing vapour differently from the others. In this fact, there is an analogy, not hitherto noticed, with Moser's images.

Renouncing metallic iodized plates, I was led to examine the action of electricity on photographic papers. Their electric sensibility is extreme.

I take a sheet of paper, having a uniform coating of *bromide of silver*, and which is very dry. After having placed or pasted it on an insulated metallic plate, connected with the conductor of the electrical machine, a very fine metallic point, which is held in the hand, and *electrized negatively by induction*, is presented to the electrized paper, at a distance of one or two millimètres. Opposite to the point, there is immediately formed a round spot of a blackish brown colour, which follows all its movements, and which may be extended at pleasure. The discolouration thus obtained has a deep brown shade, like that generated by light; and producing, when the point is slowly moved, the effect of an artist's stump. The experiment succeeds very well with a little bundle of fine platinum wires, tied to a metal handle.

The metallic point may also be placed *in contact* with the paper, and be passed gently along its surface; the discolouration is then deep black, limited to the points which are touched, and the effect is that of a drawing pencil. . . . To prevent the point's tearing the paper, a wire is secured in the axis of a glass capillary tube, the lower extremity of which is melted in order to produce adhesion; and the protruding part of the wire is cut off; the tube and the point then pass freely along the paper.

The experiment does not succeed, when the paper is slightly moist.

The bromide of silver, which is so sensitive to negative

Digitized by Google

electricity, does not undergo any *apparent* alteration, when exposed to the stream of positive electricity, which flows from a point attached to the conductor of the electrical machine.

I finally proved that the influence of electricity takes place, in perfect darkness, upon papers which have been prepared during the night; and that, consequently, it is totally independent of all previous or simultaneous action of luminous rays.

Papers prepared with nitrate of silver only, or with chloride of silver, have little electric sensibility. Papers covered with iodide of silver, which are but little sensitive to the action of light, are, on the contrary, very sensitive to the electric fluid. They present, beyond the others, this peculiarity, that they are affected, in a different manner it is true, both by the electricity from a positive point, and by that from a negative. The negative fluid forms a roundish black spot; the positive fluid developes, in all the filaments of the paper among which it is diffused, a violet discolouration in a radiated form.

This double phenomenon is due to the decomposition of the iodide of silver. The iodine is determined to the positive point, and produces the violet colour; the reduced silver is determined at the other point, and causes the black spot. To a decomposition of the same kind, must also be attributed the action of electricity on papers prepared with bromide of silver; and if, in this case, no sensible discolouration is manifested about the positive point, it is because the bromine, which is liberated there, disappears, on account of its great volatility.

The following curious experiment has confirmed me in this idea. I exposed a paper, prepared with bromide, to the direct action of the solar rays, until its tint became as deep as possible; I then subjected it to the action of two metallic points, one connected with the conductor of the machine, the other with the earth. The slate-coloured shade of the paper immediately became black around the negative point, and formed a rounded spot; while, opposite to the positive point, there appeared a kind of star, which was white, and very delicate, and indicating, by its ramifications, the radiating distribution of the vitreous electricity on the surface of the fibres of the paper. On reversing the order of the connections, and making the vitreous fluid pass to the black spot, and the resinous to the white star, the latter became black, and the former white. A fact worthy of observation is, that light acts very slowly on the white stars produced by the positive electricity, and that an exposure of more than three hours to the direct rays of

Digitized by Google

the sun, although reducing their brilliancy, was not sufficient to obliterate entirely all traces of them.

In the last place, I investigated, in my memoir, the action which the discharge of the Leyden jar exercises on photographic papers.

On making the experiment of piercing paper, the paper is perforated, and, on the bromized side, the hole is surrounded by a brown halo, which has the same appearance, whether the positive or negative coating is presented to it. This discolouration, produced indifferently by either coating of the Leyden jar, appears to me a new confirmation of the principle, that electricity is transmitted by a molecular vibratory motion, and not by a motion of transfer. In support of this principle, another and a more remarkable fact of discolouration, obtained on photographic papers, by the spark of the condenser, is as follows:—Instead of passing the discharge through the paper by means of two opposed metallic points, I made it pass over its surface, by placing the two points of a universal discharger in contact with the prepared surface. The paper must be dry, and be supported on an insulating stand. The spark of a highly charged jar is passed, from point to point, along a distance of four, five, and even six centimètres, and the trace of this spark is instantly impressed upon the paper, by a reddish train, which records all its windings and sinuosities, and which resembles an actual scratch. It appears to me an interesting circumstance, thus to have obtained, notwithstanding the very fugitive character of its appearance, the form of the electric spark, so capriciously broken as it is, traced out by itself. . . . . Another infallible mode of succeeding, is to place the paper vertically between the two points, one above, the other below, at several centimètres apart. The electric fluid glides over the paper, it pierces it on the level of the negative point, and leaves on its surface a long sinuous train. On making the experiment in vacuo, a much wider spot is obtained, but it is scarcely visible on account of the diffusion which the electric fluid acquires.

From what has preceded, may be deduced an equally simple and infallible means of obtaining electric pictures, which I call *Electrographs*. The principle consists in multiplying the number of sparks, which impinge upon the surface of the photographic paper, following the form of a design, in order to multiply the spots which are produced. For example, on the surface of a spotted-plate, I place a sheet of *dry* paper, prepared with bromide or iodide of silver, and I retain it by means of a glass plate slightly pressed against it. I then pass the discharge of a powerful Leyden jar along the metallic

Digitized by Google

ribbon; each solution of continuity is marked by a spark; and spots are formed on the paper at all the corresponding points. A very exact representation of the design which is traced on the plate, is thus obtained.

The impression of electric sparks produced with all their sinuosities, the new system of electographs which are the result, and the rapid discolouration of sensitive papers by the electric fluid, which passes from a point, are experiments which appear to me deserving henceforth of a place in the series.—[A.]

XXXI. *On the Calorific Effects of Magneto-electricity, and on the Mechanical Value of Heat.* By J. P. Joule, Esq. Read before the British Association at Cork;* Communicated by the Author. From *The Philosophical Magazine.*

(ABSTRACT.)

After alluding to magneto-electric currents as possessed of calorific properties, like currents from other sources, the author states that "when we consider heat, not as a *substance*, but as a *state of vibration*, there appears to be no reason why it should not be induced by an action of a simply mechanical character, such, for instance, as is presented in the revolution of a coil of wire before the poles of a permanent magnet." He adds, that all experiments hitherto made on this subject "refer to a particular part of the circuit only, leaving it a matter of doubt whether the heat observed was *generated*, or merely *transferred from the coils* in which the magneto-electricity was induced, the coils themselves becoming cold." This view did not seem improbable, from some facts he had elsewhere established, which appeared to indicate "that *arrangement* only, not *generation* of heat, takes place in the voltaic apparatus;" and from Peltier's experiment, in which the cold, produced by the passage of electricity from bismuth to antimony, indicated a transfer and not a *generation* of heat in thermo-combinations.

The rotating armature, with which he commenced his experiment, was thus made; "Six plates of annealed hoop-iron, each eight inches long, one inch and one-eighth broad, and one-sixteenth of an inch thick, were insulated from each other by slips of oiled paper, and then bound tightly together by a ribbon of oiled silk. Twenty-one yards of copper wire, one-eighteenth of an inch thick, well covered with silk, were

* Vide Elec. Mag., No. II. p. 138.

Digitized by Google

wound on the bundle of insulated iron plates, from one end of it to the other and back again, so that both of the terminals were at the same end." A glass tube, closed at one end, was provided, to contain this electro-magnet, and also the water, which by its change of temperature was to indicate the heat or cold evolved by the induced current, while *in* the rotating coil. By proper arrangements, the tube was made to rotate horizontally between the poles of an electro-magnet, the terminal wires of the armature being prolonged to dip into the mercury of a commutator, consisting of two semi-circular grooves. Every precaution was taken to prevent radiation and convection of heat. The electro-magnets, between which the armature was made to revolve in the first experiments, were bars, slightly bent at the ends, each being "one yard six inches long, three inches broad, and half an inch thick. The wire which was wound upon them, was one-twentieth of an inch thick; it was so arranged as to form a six-fold conductor, a hundred yards long."

"The following," says the author, "is the method in which my experiments were made:—having removed the revolving piece from its place, I filled the tube containing the small compound electro-magnet with nine ounces and three-quarters of water. After stirring the water until the heat was equably diffused, its temperature was ascertained by a very delicate thermometer, by which I could estimate a change of temperature equal to about one-fiftieth of Fahrenheit's degree. A cork, covered with several folds of greased paper, was then forced into the mouth of the tube, and kept in its place by a wire passing over the whole, and tightened by means of one or two small wooden wedges. The revolving piece was then restored to its place as quickly as possible, and revolved between the poles of the large electro-magnets for a quarter of an hour, during which time the deflections of the galvanometer, and the temperature of the room were carefully noted. Finally, another observation with the thermometer detected any change that had taken place in the temperature of the water."

Although the best means of averting the effects of radiation and conduction had been taken, it was found that the water *lost* heat. Without stopping to inquire the cause of this, means were adopted for eliminating it from the general effect, by repeating each experiment, *without* the influence, as well as *under* the influence of the inducing magnets.

The *first* series of experiments were made by converting the bars above mentioned into electro-magnets by a current from a series of six Daniell's cells, twenty-five inches high,

Digitized by Google

and five inches and a half in diameter; and connecting the two cells of the commutator with a galvanometer, having a coil of five turns, a foot in diameter, and a needle six inches long. The galvanometer was placed well away from the influence of the electro-magnets; the rotation during each experiment was continued for exactly a quarter of an hour.

The mean of two experiments gave a *loss* of 0°·05, when the rotation, at six hundred turns per minute, was made, *not under* the inducing influence of the magnets; (this was the loss already alluded to;) and a *gain* of 0°·05 when the rotation was made *under* the influence of the magnets. The corrected result gave a *gain* of 0°·1 of heat *in* the rotating coil. The mean deflection of the galvanometer was 22° 30′. By means of a table, constructed from previous experiments, the deflections could be converted into *quantities of current*, "that quantity of current being called *unity*, which, passing equably for an hour of time, can decompose a chemical equivalent expressed in grains." The value of the above deflection on this scale was 177 of magneto-electro current.

Having thus proved the production of heat *in* the coil, the author renews the experiments by aid of a more powerful electro-magnet, which, on acoount of his believing it to possess greater power of attraction from a distance than any other on record, he describes in detail.

"A piece of half-inch boiler plate iron was cut into the shape. Its length was thirty-two inches, its breadth in the middle part, eight inches, at the ends [near which it sloped off] three inches. It was bent nearly into the shape of the letter U, so that the shortest distance between the poles was slightly more than ten inches.

"Twenty-two strands of copper wire, each one hundred and six yards long, and about one-twentieth of an inch in diameter, were now bound tightly together with tape. The insulated bundle of wires, weighing more than sixty pounds, was then wrapped upon the iron, which had itself been previously insulated by a fold of calico.

"In arranging tne voltaic battery for its excitation, care was taken to render the resistance to conduction of the battery equal, as nearly as possible to that of the coil, Professor Jacobi having proved that to be the most advantageous arrangement. Ten of my large Daniell's cells, arranged in a series of five double pairs, fulfilled this condition very well, producing a magnetic energy in the iron superior to anything I had previously witnessed. I will mention the results of a few experiments in order to give some definite idea of it.

Digitized by Google

"1st. The force with which a bar of iron, three inches broad and half an inch thick, was attracted to the poles, was equal, at the distance of one-sixteenth of an inch, to one hundred pounds; at a quarter of an inch, to thirty pounds; at half an inch, to ten pounds and a-half; and at one inch, to four pounds, thirteen ounces. 2nd. A small rod of iron, three inches long, weighing one hundred and forty-eight grains, held vertically under one of the poles, would jump through an interval of one inch and three-quarters; a needle three inches long, weighing four grains, would jump from a distance of three inches and a quarter."

For the *second* series of experiments, in which the magneto-electric current was induced in the rotating coil, by this more powerful electro-magnet, a galvanometer, of only one turn of thick copper wire was used. The general results of several experiments, after eliminating the loss, as before, and making the requisite corrections, was a deflection of 22° 49′=0·902 of cur. mag.-elect., and a gain in the coil of 1°·84 of heat.

A *third* series of results were obtained by exciting the same electro-magnet with four cells of the battery in a double series. The deflection was 38° 45′=·418 of cur. mag.-elect., and the gain of heat 0°·45.

The *fourth* series resembled the second with the exception that now the galvanometer and other extra parts connected with it were dismissed from the arrangement, so that the whole effect of the magneto-electricity might be obtained. The gain of heat in this case was 2°·39. In the absence of the galvanometer, the quantity of current was calculated, by means of the ratio of resistance, (1 : 1·13,) between the circuit, as it now existed, and as it existed before, to be 1·019, which is the corresponding ratio to ·902 of the *second* series of experiments.

The *fifth* series was made by the substitution of *steel* magnets for the electro-magnets. Two such were constructed of thin plates of hard steel, according to the process recommended by Dr. Scoresby.* The attractive force was "sufficiently powerful to overcome the gravity of a small key weighing forty-seven grains, placed at the distance of three-eighths of an inch." The corrected results were a deflection of 27° 20′=·236 of cur. of mag.-elect., and a gain of 0°·1 of heat.

A *sixth* series were now made, as in the fourth, with the galvanometer excluded; and the gain of heat was 0°·21. The ratio between the circuit in which the galvanometer was included, and that from which it was excluded, being as

* Vide review of his work in the present number of Elec. Mag.

Digitized by Google

1·44 : 1, the calculated quantity of current of magneto-electricity, in the present case, is given, 0·34.

In order to ascertain whether any heat was induced in the iron of the rotating electro-magnet, by means of electric currents in each plate, experiments of the second series were made, which gave 0°·28 as the quantity of heat evolved by the iron alone. The author then continues :—

"We are now able to collect the results of the preceding experiments so as to discover the laws by which the development of the heat is regulated. The fourth column of the following table, containing the heat due to the currents circulating in the iron alone, is constructed on the basis of a law, which we shall subsequently prove, viz., *the heat evolved by a bar of iron, revolving between the poles of a magnet, is proportional to the square of the inductive force.* Column 5 gives the heat evolved by the coils of the electro-magnet alone. No elimination is required for the results of series Nos. 5 and 6, because in them the iron of the revolving electro-magnet was subject to the influence of the steel magnets in the interpolating, as well as in the other experiments."

TABLE I.

Series of Experiments.	Current Magneto-electricity.	Heat actually evolved.	Correction for currents in the iron.	Corrected heat.	Squares of numbers proportional to those in column 2.	Heat due to voltaic currents of the intensities given in column 2.	The numbers of col. 7 multiplied by four-thirds.
No. 1.	0·177	0°·10	0°·02	0°·08	0°·062	0°·040	0°·053
No. 2.	0·902	1 ·84	0 ·28	1 ·56	1 ·614	1 ·040	1 ·386
No. 3.	0·418	0 ·45	0 ·09	0 ·36	0 ·346	0 ·224	0 ·299
No. 4.	1·019	2 ·39	0 ·28	2 ·11	2 ·060	1 ·327	1 ·769
No. 5.	0·236	0 ·10		0 ·10	0 ·109	0 ·071	0 ·091
No. 6.	0·340	0 ·21		0 ·21	0 ·229	0 ·148	0 ·197
1	2	3	4	5	6	7	8

"On comparing the corrected results in column 5 with the squares of magneto-electricity given in column 6, it will be abundantly manifest that *the heat evolved by the coil of the magneto-electrical machine is proportional* (*cæteris paribus*) *to the square of the current.*"

Digitized by Google

Column 7 is constructed on the basis of some careful experiments in which the mean of heat evolved by passing voltaic currents through a small coil, was 5°·88 for 2·145 of current. The same datum is used for similar calculations in the sequel.

Bearing in mind that the magneto-currents are *pulsatory*, and the voltaic *uniform*, the author could not compare column 5 with column 7, until he had made a further correction. He found, on examination, that the magneto-current gave little variation during three-fourths of the revolution of the electro-magnet. But that "the remaining one-fourth (during which the revolving electro-magnet passes the poles of the stationary electro-magnet) is occupied in the conversion of the electricity. In the experiments, all flow of electricity, during this one-fourth is cut off by the divisions of the commutator." He, therefore, multiplies column 7 by four-thirds, in order to obtain column 8, which he is now able to compare with column 5. As the flow of magneto-electricity, however, is not entirely *constant*, during the active three-fourths of the revolution, but rises and falls as the position of the rotating coil changes, column 8 is "somewhat under the truth."

"Bearing this in mind in the comparison of columns 5 and 8, it will, I think, be admitted that the experiments afford decisive evidence that *the heat evolved by the coil of the magneto-electrical machine is governed by the same laws as those which regulate the heat evolved by the voltaic apparatus; and exists also in the same quantity under comparable circumstances.*"

In order to obtain the value of the heating power of magneto-electricity *beyond* the coil, five or six yards of one-fortieth inch copper wire were included in the arrangement employed in series 2. The mean of two experiments gave 0·298 of magneto-current, and 0°·43 of heat. A quantity of voltaic current, equalling 2·02, evolved 12° of heat in the same wire. "Reducing this to 0·298 of current, we have $(\frac{0{\cdot}298}{2{\cdot}02})^2 \times 12° = 0°{\cdot}261$." This multiplied by $\frac{4}{3}$, as before, gives 0°·348; which is less than (0°·43) the experimental results, as the theory demands.

"I now proceeded," continues the author, "to consider the heat evolved by voltaic currents, when they are counteracted or assisted by magnetic induction. For this purpose, it was only necessary to introduce a battery into the magneto-electrical circuit; then, by turning the wheel in one direction, I could oppose the voltaic current; or, by turning it in the other direction, I could increase the intensity of the voltaic—by the assistance of the magneto-electricity. In the former case, the apparatus possessed all the properties of the electro-

Digitized by Google

magnetic engine; in the latter, it presented the reverse, namely, the *expenditure* of mechanical power."

A *seventh* series of experiments was made, in which the steel magnets were used as the inductive force. And the current, from two cells in series, of the Daniell's arrangement formerly described, was passed through the revolving electro-magnet, and the galvanometer; and the revolutions, given as before by mechanical means, were made in the direction which the rotating part of the apparatus would have taken, had it moved by the power alone of the current passing along it. The corrected result gave 0·864 of current, and 1°·5 gain of heat.

In the *eighth* series, other things remaining as before, the direction of revolution was *reversed*, so as to superadd the magneto-electricity to the voltaic, and so *increase* its force. The corrected mean result gave 1·346 of current, and a gain of 2°·93 of heat.

In the *ninth* series, the powerful electro-magnet was used, instead of the permanent steel magnets; other things remaining as in series seven. "The motive power of the apparatus was now so great that it would revolve rapidly, in spite of very considerable friction. In order to give the requisite velocity, it was necessary, however, to assist the motion by the hand." The corrected mean result gave 0·543 of current, and 0°·68 gain of heat.

In the *tenth* series the electro-magnet was rotated as in series eight, so as to unite the voltaic with the magneto-current, and obtain the sum of the effects. The result was 1·845 of current, and 6°·06 gain of heat.

In the *eleventh* series the current from one cell only of Daniell's was made to pass round the rotating magnet; and the rotation was given so as to oppose the two currents. A revolution of 375 turns per minute gave no galvanometric deflection, and consequently no current; but 0°·12 of heat was evolved in the electro-magnet.

When, in the *twelfth* series, the rotations were increased to 600 per minute (the standard number employed throughout), 0·34 of current in an opposite direction was obtained, and 0°·45 of heat was developed in the coil.

In reference to these experiments, the author says:—"The magneto-electricity was so intense, at a velocity of 600 per minute, as to overpower the intensity of the single cell, causing the needle to be permanently and steadily deflected to between 9° and 10° in the opposite direction. The command of the magneto-electricity, over the voltaic current arising from one cell, was beautifully illustrated by the sparks at the

Digitized by Google

commutator. Turning slowly they were bright and snapping;* increasing the rapidity of revolution, they decreased in brightness, until at a velocity of about 370 per minute, they ceased altogether. They were plainly visible again when the velocity reached 600 per minute."

The results of these experiments are collected in Table II. "The correction for heat evolved by the iron of the revolving electro-magnet is estimated at 0°·18, the product of 0°·28 by $(\frac{4}{5})^2$; because in the above experiments the large electro-magnet was excited by $\frac{4}{5}$ of the battery used when 0°·28 was obtained. No correction is needed for the series, in which the steel magnets were used; because they remained in their places, during the interpolating experiments."

TABLE II.

Series of Experiments.	Current Magneto-electricity.	Heat actually evolved.	Correction for current in the iron.	Corrected Heat.	Squares of Numbers proportional to those in column 2.	Heat due to voltaic currents of the intensities given in column 2.	The numbers of col. 7 multiplied by four-thirds.
No. 7	0·864	1°·50	0°	1°·50	1°·291	0°·954	1°·272
No. 8	1·346	2 ·93	0	2 ·93	3 ·133	2 ·316	3 ·088
No. 9	0·543	0 ·68	0 ·18	0 ·50	0 ·510	0 ·377	0 ·503
No. 10	1·845	6 ·06	0 ·18	5 ·88	5 ·886	4 ·351	5 ·801
No. 11		0 ·12	0 ·18	0 ·06			
No. 12	0·340	0 ·45	0 ·18	0 ·27	0 ·200	0 ·148	0 ·197
1	2	3	4	5	6	7	8

"It will be observed, that these theoretical results [contained in col. 8], are not so much inferior to the experimental results of col. 5, as they were in Table I. The principal reason of this arises from the mixture of the constant effect of the battery with the variable magneto-electrical current."

The author refers to a comparison of columns 6 and 8 with 5, as showing that the law of the square of the electric current still maintains, whether magnets be opposed to, or asso-

* The most splendid sparks are obtained, when the voltaic is assisted by the magneto-electricity, by turning an electro-magnetic engine, in a direction contrary to the attractive forces.

Digitized by Google

ciated with, voltaic electricity; and he shows that "therefore the heat due to a given chemical action, is subject to an increase or to a diminution, directly proportional to the intensity of the magneto-electricity assisting or opposing the voltaic current."

"*We have, therefore,*" he adds, "*in magneto-electricity an agent capable by simple mechanical means of destroying or generating heat.* In a subsequent part of this paper I shall make an attempt to connect heat with mechanical power, in absolute numerical relations."

On the Heat evolved by a Bar of Iron, rotating under Magnetic Influence.

The electro-magnet was now taken out of the glass tube, and its place supplied by a cylinder of iron 8 inches long and $\frac{3}{4}$ in. in diameter. In the first experiments of this form, that is, the *thirteenth* series, the large electro-magnet was excited by ten cells of the battery, in a double series of five; a galvanometer was included in the circuit, in order to indicate the electric force applied as the exciting cause. The result was 9·85 of current, and 1°·31 gain of heat. The *fourteenth* series was varied by using six cells in three double pairs. The result was 6·77 of current, and 0°·56 gain of heat. The *fifteenth* series, with two cells in series of the battery, gave 4·17 of current and 0°·16 gain of heat. The results are collected in Table III.

TABLE III.

Series of Experiments.	Current employed in exciting the electro-magnet.	Heat evolved.	Square of numbers proportional to those of col. 2.
No. 13.	9·85	1°·31	1·2290
No. 14.	6·77	0 ·56	0·5807
No. 15.	4·17	0 ·16	0·2203
1	2	3	4

The author then mentions that Professor Jacobi, and himself also, had discovered "that the attraction of electro-magnets, either towards one another or for their armatures, is (below the point of saturation) proportional to the square of the electric force." He adds: "The *magnetism* in an electro-magnet is therefore simply as the electric force. Consequently, the numbers in column 2 are proportional to the magnetic virtue of the

Digitized by Google

electro-magnet. But, on comparing columns 3 and 4 together, it will be seen that the heat evolved is as the square of the electricity. Therefore, *the heat evolved by a revolving bar of iron is proportional to the square of the magnetic influence, to which it is exposed.*"

He infers from the above experiments that heat would be evolved from the rotation of non-magnetic substances in proportion to their conducting power; but he had not made any experiments on the subject.

PART II.

On the Mechanical Value of Heat.

"Having proved that *heat* is *generated* by the magneto-electrical machine, and that, by means of the inductive power of magnetism, we can *destroy* or *increase* at pleasure the *heat* due to chemical changes, it became an object of great interest to inquire whether a constant ratio existed between it and the mechanical power gained or lost. For this purpose, it was only necessary to repeat some of the previous experiments, and to ascertain, at the same time, the mechanical force necessary in order to turn the apparatus."

This he managed by causing the descent of weights to give the requisite velocities. On repeating series No. 2, he found that 4 lbs. 12 oz., descending with a velocity of 517 ft. per 15 minutes, gave the standard 600 revolutions per minute, (friction and resistance having been eliminated), and produced 0·983 of current electricity; equal, according to Table I, to $(\frac{983}{1000})^2 \times 1°{\cdot}56 = 1°{\cdot}85$ of heat. This, corrected for the resistance of the coil, compared with the whole circuit, and for the heat evolved by the iron, and by the spark at the commutator, gave 2°·46. This heat was distributed in the electro-magnet, the glass tube and the water, the latter of which only weighed ·61 lbs. By the necessary reductions, in order to refer this to a pound of water, he found the quantity of heat evolved by the power which can raise 4 lbs 12 oz. to the perpendicular height of 517 ft., would raise the temperature of 1 lb. of water 2°·74. "1° of heat per pound of water is, therefore, equivalent to a mechanical force capable of raising a weight of 896 lbs. to the perpendicular height of one foot." Other analogous experiments were made, which gave 1001 lbs., 1040 lbs., 910 lbs., and 587 lbs. On account of the complicated character of these experiments, a more simple form was now adopted.

In place of the electro-magnet, a bar of iron, covered with electrotype copper, was placed in the glass tube, and was

Digitized by Google

rotated between the poles of the large electro-magnet, excited by ten cells, in five double pairs, which gave for the *sixteenth* series, 10·93 of inducing current. The mean of heat gained was 2°·73. In order to get the equivalent mechanical force for this, experiments were made with ten cells of the battery, in a double series of five, which gave an inducing current of 7·91 in value, and consumed a mechanical force equal to 4·2 lbs., raised 517 ft.; also with a battery of five in series, which gave 7·01 of current, and consumed a mechanical force equal to 2·38 lbs.

By calculation from these several data, in the one case 742, and in the other 860 lbs, raised to the height of one foot, would communicate one degree of heat to a pound of water. The author then says:—

"I admit that there is a considerable difference between some of the results, but not, I think, greater than may be referred, with propriety, to mere errors of experiment. I intend to repeat the experiments with more powerful and more delicate apparatus. At present, we shall adopt the mean result of the thirteen experiments given in this paper, and state generally that,—

"*The quantity of heat capable of increasing the temperature of a pound of water by one degree of Fahrenheit's scale is equal to, and may be converted into, a mechanical force capable of raising* 838 *lbs. to the perpendicular height of one foot.*"

Two conclusions occur to him in connection with the convertibility of heat and mechanical power into one another, the one as respects the duty of steam-engines, the other as to the practicability of employing electro-magnetism as a motive force.

1. From a statistical table given by Mr. Russel, "it appears that, in the Cornish boilers at Huel Towan and the United Mines, the combustion of 1 lb. of Welsh coal gives 183° to a cubic foot of water..... But we have shown that 1° is equal to 838 lbs. raised to the height of one foot. Therefore, the heat evolved by the combustion of a pound of coal is equivalent to the mechanical force capable of raising 9,584,206 lbs. to the height of one foot, or to about ten times the duty of the best Cornish engines."

2. His experiments had shown him that a pound of zinc in a Daniell's battery produces a current which will communicate 1320° of heat, and a pound in a nitric acid battery, a current communicating 2200° to a pound of water. Therefore, he says, "*the mechanical forces of the chemical affinities which produce the voltaic currents in these arrangements, are, per pound of zinc, equal respectively to* 1,106,160 *lbs., and*

Digitized by Google

1,843,600 *lbs. raised to the height of one foot.* But since it will be practically impossible to convert more than about one half of the heat of the voltaic circuit into useful mechanical power, it is evident that the electro-magnetic engine, worked by the voltaic battery at present used, will never supersede steam in an economical point of view."

In a postscript he says, that "we shall be obliged, after all, to admit that Count Rumford was right in attributing the heat evolved by boring cannon, to friction, and not in any considerable degree to any change in the capacity of the metal." He states that, he has himself obtained evolution of it by the passage of water through tubes of narrow bore, in the proportion of 1° of heat per pound of water from a mechanical force capable of raising 770 lbs. to the height of 1 ft.; and he considers "that, wherever mechanical force is expended, an exact equivalent of heat is *always* obtained." And with reference to animal heat, which he thinks must still be referred to the chemical changes going on in the system, he says:—"If the animal were engaged in turning a piece of machinery, or in ascending a mountain, I apprehend, that in proportion to the muscular effort put forth for the purpose, a *diminution* of the heat evolved in the system by a given chemical action would be experienced."

He states that the experiments detailed in this paper, do not militate against, though they modify, his former views of the electrical origin of chemical heat. He thus expresses his present opinions:—

"I now venture to state more explicitly, that it is not precisely the attraction of affinity, but rather the mechanical force expended by the atoms in falling towards one another, which determines the intensity of the current, and consequently the quantity of heat evolved; so that we have a simple hypothesis, by which we may explain why heat is evolved so freely in the combination of gases, and by which, indeed, we may account "latent heat" as a mechanical power, prepared for action as a watch-spring is when wound up. Suppose, for the sake of illustration, that 8 lbs. of oxygen and 1 lb. of hydrogen were presented to one another in the gaseous state, and then exploded, the heat evolved would be about 1° of Fahr. in 60,000 lbs. of water, indicating a mechanical force expended in the combination equal to a weight of about 50,000,000 of lbs. raised to the height of 1 ft. Now, if the oxygen and hydrogen could be presented to each other in a liquid state, the heat of combination would be less than before, because the atoms in combining would fall through less space. The hypothesis is, I confess, suffi-

Digitized by Google

ciently crude, at present; but I conceive that ultimately we shall be able to represent the whole phenomena of chemistry by exact numerical expressions, so as to be enabled to predict the existence and properties of new compounds."

XXXII. *Observations on Natural Voltaic Pairs.* By the Editor.

There is a recent* paper by Mr. R. W. Fox, describing the electro-motive power of native minerals associated into a voltaic pair, as they lie in the mine; the experiments are interesting, as being precisely analogous to those already before our readers,† wherein metals have been buried in the earth. Copper and iron pyrites in two separate veins, whose direction was E. and W., and from 14 to 18 fathoms apart, were respectively attached to about 50 fathoms of copper wire; the wire was led to the surface of the earth; and the apparatus for experiment was interposed in the circuit. The permanent deflection given to a rough galvanometer of 48 coils was 14° to 15°; that given to an astatic galvanometer of 140 coils, was about 40°: the deflections remained the same, whether contact with the ore was effected by platinum or zinc, by a plate or by a point. If, while one pair of ore-points were acting on the galvanometer, another neighbouring pair were formed into a circuit by fresh and independent wires, including the other galvanometer, the deflection of the first galvanometer was reduced, and that of the second attained a few degrees less than its ordinary angle; but, when either circuit was interrupted, the standard maximum deflection was regained. Both wires connected with one galvanometer did not increase its deflection. When a pair of zinc and copper, excited with moist cloth, was interposed in the circuit, so as to generate a current *co-incident* with that from the earth, the deflection was reduced several degrees; when the interposed pair was placed so as to act *counter* to the original current, the galvanometer at times returned to Zero, and sometimes passed that point. A separate examination showed a deflecting power in favour of the mine over the pair of zinc and copper. When a horse-shoe electro-magnet was included in the circuit, and contact was

* Vide also Proceed. Geol. Soc., June 1, 1842; and Tenth Report Cornwall Polyt. Soc. p. 103.

† Vide *Elec. Mag.*, No. 1. p. 52.

Digitized by Google

made and broken alternately, a compass-needle was caused to oscillate in an arc of 70°. A solution of hydriodate of potash was decomposed, after being included for rather more than a day. When sulphate of copper was placed in each arm of a U tube, having a porous clay tamping, and the circuit was kept closed by silver wire for a few days, the endosmose action raised the column connected with the negative wire one-eighth of an inch, whilst the other column was lowered to an equal degree. When copper pyrites was used instead of wire, that piece contained in the negative cell, in two or three days had its surface gradually changed to vitreous copper. This also occurred when carbonate of soda, or when common salt was substituted for the copper solution. When several weeks of action were permitted, oxide of iron was occasionally found on the negative pyrites. An engraved plate and a sheet of copper were placed in a solution of sulphate of copper and connected with the respective wires of this native pair; after an action of nearly two months, *an electrotype copper-plate* $1\frac{1}{2}$ *in. long,* $1\frac{1}{4}$ *in. wide, and* $\frac{1}{60}$ *in. thick,* was obtained; to use Mr. Fox's words, *Vi Insitâ Terræ.* When one wire was in contact with *ore* in one vein, and the other wire touched the *rock* in the other vein, feeble currents passed, owing, no doubt, to the moisture of the rocks. The action was most decided when the place of contact with the rock was near the ore. Several times, on rubbing the wire against the wall of one of the veins, or the sides of a "cross-cut," sudden increased deflections occurred; and, when the spots where this was observed were afterwards broken away, iron pyrites was invariably found imbedded there; "and," as Mr. Fox remarks, "there can be no doubt that the smallest branch of copper or lead ore might have been detected in like manner." When both wires were in contact with the respective rocks, the currents were too feeble to be depended on.

The above interesting experiments appear to reduce themselves under the same general law which regulates all voltaic action: the two veins containing, as they evidently do, ores holding different ranks in the electric scale, represent the two plates of a voltaic pair; the moisture of the earth, and the water, which is described as flowing into the mine, is the exciting liquid. The distance between the elements, 100 feet, reduces, but does not destroy, the electro-motive power. Mr. Bain's experiments in Hyde Park are confirmations to these; they all reveal to us a great extension of the limits within which we have been willing to consider that electro-motive power is confined. Mr. Fox says "I have long ago seen a *very feeble* current act on a sensitive galvanometer

Digitized by Google

after it had traversed nearly a quarter of a mile of strata, and stronger currents would probably be detected in like manner, after having passed many times that distance under the surface." Mr. Kemp generated a current with a voltaic pair, the plates of which were several hundred feet apart; Mr. Bain, at the distance of a mile. But, as all known phenomena convince us that the power is reduced as the distance increases, we must hesitate before we accept the inference thus expressed by Mr. Finlaison: "If a copper wire, one-sixth of an inch in thickness, be imbedded in a bar of boiling asphaltum, and sent along the railway (for its better protection,) from London to Liverpool—if two tons weight of zinc plates be immersed in the Mersey at Liverpool, and attached to that end of the wire, and if one ton weight of copper be sunk in the river Thames, and attached to this end of the wire, no rational man can doubt that an electric current would be established of ten times the power necessary to work a telegraph."* We have very strong doubts on this point; and are inclined to think the 200 miles, above named, as very far exceeding the limits of the available action of any pair of metals. It is not because recent researches have extended the limits from yards to hundreds of yards, that we are henceforth to ascribe no bounds to the action; on the contrary, the very feeble effects produced at the comparatively small distances before us teach us to expect that, not only would no available action occur at great distances, but scarcely any action at all.

To return to Mr. Fox's experiments. The electro-motive minerals, by laws familiar to electricians, suffer chemical change in proportion to the electric development; and in the case before us they are put into condition to effect that development by the *artificial* application of the copper wires. It only remains to conceive some *natural* substitute for the said wire, to have an insight into the secret workings of the laboratory of nature: this substitute is present, from the very disorder, as it at first appears, of the earthy strata; and thus, what to the casual observer seems "discord" is, in truth, "harmony not understood;" it is the very means adopted by nature to elaborate in the womb of the earth those many productions which have become so essential to the happiness of civilized man. Moreover, as all voltaic effects are attended by an equivalent chemical change in the materials of the electro-motor, it incontrovertibly follows that such effects will last no longer than the generating elements remain; and that these elements will, independently of local action, be

* Vide Mr. Finlaison's Book, p. 34.

Digitized by Google

changed in proportion to the electricity generated. Yes, and some of these changes, as, for instance, the formation of oxide of zinc on a zinc plate, may very soon operate in reducing the original electro-motive power of the pair,—indeed, this *has* actually occurred in some experiments made by a friend of ours; so that, although our views of the distance which may intervene between the generating plates of a voltaic pair, have been extended by the recent experiments to which we have alluded, we are physically sure that the author draws a false inference, who says, "that by placing plates of positive and negative metallic surfaces in the earth or in the water at great distances; then connecting these by a well-insulated wire, he is enabled to discard galvanic batteries altogether, and to produce an everlasting and unvarying flow of electricity, proportionate in power to the amount of metallic surface." It cannot be "everlasting," for it is limited in quantity and duration by the mass of the positive metal; it cannot be "unvarying," for it suffers a gradual decay by the gradual consumption of the same metal C. V. W.

SCIENTIFIC MEETINGS.

ROYAL SOCIETY.

On the Gas Voltaic Battery.—Experiments made with a view of ascertaining the rationale of its action, and its application to Eudiometry. By W. R. Grove, Esq., M.A., F.R.S., &c. Received March 27th. Read May 11th, 1843.

(ABSTRACT FROM THE PHIL. TRANS., PART 2, 1843.)

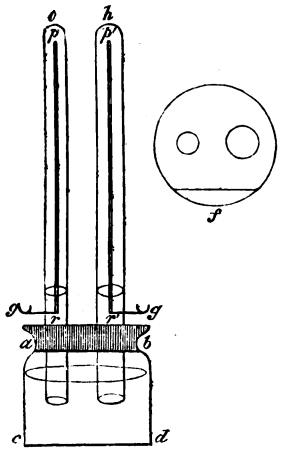
After referring to his original account of a voltaic battery, in which the active ingredients were gases,*—a battery, which consisted of a series of tubes inverted over acid water, each containing platinized platinum, and alternately charged with oxygen and with hydrogen;† by which combination all the characteristic indication of electric action were evolved, as shock, magnetism, attractions, light, heat, and electrolytic action, Mr. Grove mentions, that the apparatus which he then employed, did not enable him to attain any precise accuracy of measure, as to the volumes of gas absorbed, or to prove that Faraday's law of definite electrolysis finds no exception in the gas battery.

He now renews the inquiry, and, by means of apparatus constructed on a more favourable plan, he has not only been enabled to verify this law, but to extend his researches into the nature of gaseous voltaic action.

* Vide Phil. Mag., Dec. 1842. † Vide Elec. Mag., p. 58, No. I.

Digitized by Google

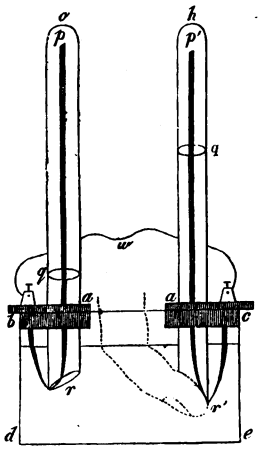
FIG. 1.



The first improvement in the construction of the apparatus is shown in Fig. 1. The glass jar *a b c d*, is closed by a wooden plug, through which pass two graduated tubes, *h* and *o*,—*h*, or that for containing the hydrogen, being double the size of *o*, or that for containing the oxygen. The plates of platinized platinum, *p p'*, are connected with platinum wires at *r r'*, which terminate in mercury cups, *g g*. The piece, *f*, of the wooden plug, can be detached for the introduction of a tube to charge *o* and *h* with the respective gases. The apparatus is represented as charged for use.

"The advantage," says Mr. Grove, "of this form over that which I shall next describe, is the facility with which the tubes are filled with liquid, and the absence of any necessity of touching the electrolyte with the fingers. On the other hand, its disadvantages are the difficulty of examining the gases after experiment, and the impossibility of doing so during experiment, without changing the electrolyte: as, in order to examine the gases, the whole apparatus must be immersed in a water-trough, and the cover with the attached tubes taken off, while the jar and the ends of the tube are under water."

FIG. 2.



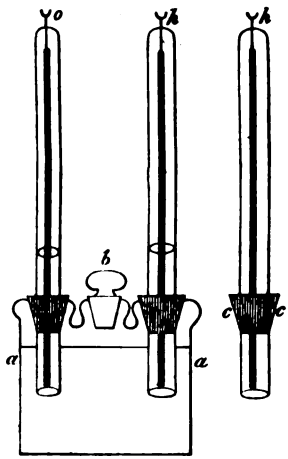
The second form, which was mostly used in these investigations, is represented in Fig. 2. The glass cells, *b c d e*, are of the form commonly employed in the nitric acid battery. The graduated tubes, *o h*, are each fixed in a separate piece of wood *a*, so that by applying the finger at *r* or *r'*, as represented by the dotted lines, either tube, with its contents, can be removed for examination.

"In this figure, the platinum foil is turned up round the edge of the tube, instead of being attached to a wire, sealed into the glass; and, instead of a mercury cup, there is a binding-screw connection; but it is obvious that this part of the arrangement may be interchanged with the other apparatus, or varied *ad libitum*. This apparatus I have found in practice to be very much more convenient than the former, from the facility of detaching either tube so as to discharge some of the gas, if it be desirable to alter the level of the water-mark, or to examine or change the gas in any of the tubes. On the other hand, it has the disadvantage of requiring the finger to be immersed in the electrolyte, which, when the latter is of an active chemical character, is unpleasant, and, in some cases, injurious."

Digitized by Google

The series, with which the investigation was conducted, consisted of a portion constructed, under Mr. Grove's direction, for the London Institution; and another portion belonging to Mr. Gassiot, which, being kindly placed at his disposal, enabled him to make his experiments on a much more satisfactory scale.

Fig. 3.



While writing this paper, a third form of apparatus occurred to him, which is given in Fig. 3. He had not had the opportunity of using it in these researches; but he describes it for the benefit of others. The cell, *a a*, is a three-necked Woulfe's bottle, closed by a stopper at *b*, and sustaining the tubes, *o h*, which are welded into glass stoppers, *c c*, the latter being ground on the outside: the platinized platinum is sealed into the tubes at *h* and *o*, and terminates in mercury cups.

"By immersing this apparatus in the water-trough, each tube, with the gas it contains, may be detached and examined separately; but its principal advantage is that, by slightly greasing the stopper and collars, it may be made perfectly air-tight; which, for reasons that will be apparent in the course of this paper, is a most material point. This apparatus, moreover, being entirely composed of glass and platinum, concentrated acid, alkaline or other corrosive solutions, may be used as the electrolyte, without damaging the apparatus, or introducing foreign matter."*

Before entering on the special matter of the present investigation, Mr. Grove mentions that, whereas, with the arrangement described in his original paper, when charged with oxygen, hydrogen, and weak sulphuric acid, he could scarcely decompose water with twenty-six cells, the superior advantages of the new arrangement enabled him to accomplish it even with four cells.

Exp. 1.—Ten cells of Fig. 2 form, were charged with oxygen, hydrogen, and acid water, and, for thirty-six hours, were allowed to electrolyze acidulated water contained in a voltameter. The general result of many repetitions of this experiment was, that the oxygen absorbed by the battery was equivalent to the oxygen evolved in the voltameter; and so of the hydrogen. But the absorbed and evolved hydrogen was in all cases more than double, that is, more than the equivalent of the oxygen. The deficiency of oxygen in the voltameter has been already traced by Faraday to its more ready solubility, and tendency to form oxygenated water; and hence the apparent surplus evolution of hydrogen. But the disappearance of a surplus of hydrogen from the battery tubes is

* Some experiments with this form are given in the P.S.

Digitized by Google

due to a local action between it and the oxygen of the air always in solution in water; which, therefore, adds nothing to the general current, though it tends to diminish the hydrogen. Mr. Grove had long ago* found that tubes charged alternately with hydrogen and with water, were active on account of this very cause. He now abstracted this local action from the general result, by placing a cell out of the circuit, and unconnected, for twenty-four hours; at the termination of which period, he found an amount of hydrogen had been absorbed, about equivalent to the surplus absorption already noticed.

Exp. 2.—With occasional exceptions, the absorption of gas in every battery cell corresponded. As the exceptions could only be due to the local action of foreign matter, an arrangement was made, in which this could be traced. Of four cells charged with sulphate of copper, the hydrogen in one was absorbed in double ratio to what occurred in the others; and, on examination, all the platinum of this cell, beneath the liquid in the hydrogen tube, was coated with copper; it appeared that a nucleus of copper had originally been deposited, doubtless upon a point where resistance was weakest; this had formed a starting point for fresh deoxidation, and, of course, at the expense of the hydrogen. Setting out of the question these cases of local interference, "the equivalent action of the battery was very beautiful."

"With fifty cells in action," Mr. Grove remarks, "there was but a trifling difference in the rise of the liquid in all the cells; and the rise of gas in the voltameter appeared so directly proportional, that an observer, unacquainted with the rationale of a voltaic battery, would have said, the gases from the exterior cells of the battery were conveyed through the solid wires and evolved in the voltameter; and, had this been the first voltaic battery ever invented, this probably would have been the theory of its action."

Exp. 3.—Mr. Grove had advanced the opinion that the active points of the gas battery were where the gas, the platinum, and the liquid met; he was now "anxious to ascertain whether the principal points of action were those which he had originally believed, or whether the gases entered into solution first, and were then electro-synthetically combined by the immersed portion of the platinum;" and, for this purpose, he prepared cells in which the platinum reached only half-way up the tubes. He found that as long as any part of the platinum was in the gaseous atmospheres, the arrangement was active; but that the action ceased, as soon as the plates were entirely immersed. "This experiment decides the question as to what is to be considered the working portion of the battery, but it does not positively decide whether solution and electrolysis are contemporaneous or successive, as it may be even said, that what have been termed the exposed parts of the platinum, are covered with a film of liquid."

Exp. 4.—A *single* pair, charged, in the usual way, with oxygen and hydrogen, was now made to decompose water, just as *one* pair of an ordinary battery does, when a *copper anode* is used. Instead,

* Phil. Mag., Dec. 1842.

Digitized by Google

however, of using a copper anode, the platinum anode was presented to an atmosphere of hydrogen: the decomposition cell was, in fact, a cell of the gas battery, having one tube charged with hydrogen for the anode, the other with acid water. As was anticipated, hydrogen was *given off* at the cathode, "the platinum in the atmosphere of hydrogen being analogous to an oxidable anode;" and the nascent oxygen of electrolysis combined with that hydrogen.

Exp. 5.—In order to extend the analogy between the gaseous and metallic batteries, three cells were charged with nitric acid and hydrogen, in the alternate tubes; the *gaseous* hydrogen, in this case, deoxidated the nitric acid, just as *nascent* hydrogen does in the nitric acid battery, and produced a current sufficient to decompose water.

Exp. 6.—In endeavouring to produce a converse case, where oxygen should be the gaseous element, the alternate tubes were charged with protosulphate of iron; but the slight action which occurred was only temporary, and in a few hours it abated. Generally, free hydrogen was more active than free oxygen.

Exp. 7.—This experiment was made chiefly in refutation of the opinion specially advanced by Schœnbein,* that hydrogen and water are the only active elements in the gas battery, and that oxygen has nothing to do with the current. This opinion originated in the fact that water and hydrogen form an active pair. But when Mr. Grove charged two similar cells each with hydrogen in one tube and water in the other, and subjected one, with the circuit closed, to ordinary atmospheric influence, and placed the other in an atmosphere exhausted of oxygen, the enclosed battery soon ceased to be active, while the exposed battery retained its power. After four days, the enclosed battery was exposed to atmospheric air, and in a quarter of an hour the action again became perceptible; "in two hours the action was equal to that of the battery which had been from the first exposed to the atmosphere." This experiment appears a conclusive negation to Schœnbein's view, for it proves that the effect obtained by a combination of hydrogen and water, is really due to the oxygen in solution. In connection with this question, Mr. Grove remarks:—

"If, on the other hand, hydrogen and water be the only active elements, what becomes of the hydrogen? If it combine with the water, we undoubtedly should by this means be able to obtain a suboxide of hydrogen,† a result of which I have not the slightest symptom in a long course of experiments on this subject. Even if we assume the action of the oxygen to be a depolarizing one, as suggested by Dr. Schœnbein, this comes to the same thing, as this depolarization can only be accounted for as being effected by the combination of the oxygen with hydrogen; and we might conversely assume this combination to be the efficient cause of the current, and the depolarization to take place in the hydrogen tubes. It seems to me that the effects at both anode and cathode are reciprocally dependent. The matter appears to me so clear that I should not have entered

* Vide Elec. Mag., No. I. p. 65; and Schœnbein's paper in the present number of Elec. Mag.

† Schœnbein believes this to be the case. Vide his paper.

Digitized by Google

into detail upon it, were it not for the published letter of Dr. Schœnbein above mentioned; and that the superiority of the hydrogen is, *primâ facie*, very striking."

Exps. 8 and 9 were with tubes charged with oxygen and protoxide of nitrogen, and with oxygen and deutoxide of nitrogen; the general results were negative.

Exp. 10 with oxygen and olefiant gas, gave a very feeble action, but furnished no satisfactory evidence "as to the equivalents of these gases, which contributed to electrolysis."

Exp. 11, with oxygen and carbonic oxide, gave definite electrolytic effects, though feeble, as compared with those from oxygen and hydrogen. One volume of oxygen and 2·3 of carbonic oxide were absorbed; and carbonic acid was produced in the solution. The true combining equivalents are 1:2; local action readily accounts for the slight variation.

Exp. 13, with oxygen and chlorine, in which oxygen is to chlorine what hydrogen is to oxygen, gave a decreasing action, without absorption of oxygen; therefore

Exp. 14 was made, in which the alternate tubes were filled with chlorine and with water, and the action was equal, and equally transitory, with that in the last experiment. Mr. Grove refers to the fact of the known power of chlorine slightly to decompose water; and to this he attributes the voltaic action. The following original and truly philosophical idea must be given in his own words:—

"There was no appearance of the platinum having been attacked in several experiments which I made with chlorine. So slight a chemical action will, however, give rise to voltaic effects, that the absence of any apparent corrosion is not conclusive. It is stated by chemists, that gaseous chlorine will not attack platinum, but that it is only when nascent it combines with this metal; *non constat*, however, that in the gas battery the chlorine at the initiatory instant of its electro-synthesis may not be in a state analogous, as to its chemical energies, to that converse state called nascent; and, therefore, we cannot venture to negative the possibility of the platinum being slightly attacked."

Exp. 15 showed chlorine to be to bromine and iodine, what oxygen is to hydrogen.

Exp. 16.—Chlorine and hydrogen decomposed water with two cells; being the most powerful gas battery. In a note, Mr. Grove says:—

"Chlorine, in its voltaic relations, may be considered as the converse of zinc, both decomposing water, but the one liberating oxygen, the other hydrogen; thus a tube of the gas battery, charged with chlorine, and having acidulated water as an electrolyte, and zinc as a positive element, forms a combination, of which one pair will decompose water. I have tried to render this combination practically useful, by charging the negative cell of a diaphragm battery with peroxide of manganese and muriatic acid; but the supply of chlorine thus obtained is insufficient for quantitative effects, though the intensity is great."

Exps. 17—19 may be passed over, as only giving negative results.

Exps. 20—23 were made in order to determine whether other gases, which can be evolved by electrolytic action, would

Digitized by Google

form a gas battery, and produce a current. Oxygen and deutoxide of nitrogen with nitric acid, oxygen and nitrogen with sulphate of ammonia, carbonic acid and carbonic oxide with oxalic acid, and hydrogen and nitrogen with sulphate of ammonia, were severally tried, but they all led to the same conclusion, that "the idea of realising a voltaic action by conversion of the ordinary effects of electrolysis was erroneous."

Exp. 24.—Since many gases, as nitrogen, had been found absolutely inactive in these combinations, the idea occurred of employing the gas battery for the analysis of air, or of mixed gases. The circuit of a single pair, charged with atmospheric air in one tube, and hydrogen in the other, was closed for several days till all action ceased, *i. e.* till all the oxygen of the air was gone. On eliminating from the result, the effects of absorption, the analysis gave twenty-one per cent. of oxygen in atmospheric air.

Exp. 25.—A single cell was charged with oxygen and with nitrogen; into the latter, a given measure of hydrogen was introduced; the circuit being closed, the action ceased when this given measure of gas had been absorbed, showing that "the voltaic action had perfectly exhausted the hydrogen and there stopped."

After mentioning some of the eudiometric advantages of the gas battery, and also its being a very simple means of obtaining nitrogen of unquestionable purity, Mr. Grove goes on to state the views which led to its discovery.

"When pure amalgamated zinc is immersed in acidulated water, the oxygen, as is well known, will not combine with the zinc; but touch both zinc and liquid with platinum, and combination ensues, the platinum being unaltered. So with a mixture of oxygen and hydrogen, the gases, although in intimate contact, will not chemically unite; but touch them with clean platinum, and more or less rapid combination ensues. Here also the platinum is unaltered. Leaving out of the case any purely hypothetical explanation, why may not effects, so similar in their character, be related in other respects?"

Exps. 26 and 27 illustrates the union of oxygen with the *hydrogen* of ammonia, at one end; and the liberation of the *nitrogen* from the ammonia, at the other. The oxygen absorbed was ·12 cub. in., which, therefore, united with ·24 of hydrogen: the nitrogen liberated was ·07 cub. in.: now ·07 nitrogen + ·21 hydrogen are the combining equivalent for ammonia, which is a result "remarkable in regard to the binary theory of electrolysis."

These experiments are followed by observations on the molecular theory of Grotthus, as illustrative of the rationale of the action. And then Mr. Grove writes:—

"It is, however, a curious circumstance, and worthy of some consideration, that the voltaic hypothesis of Grotthus, the emissive and undulatory hypotheses of light and heat, and as far as I am aware, all physical hypotheses hitherto propounded, represent natural agencies as effects of *motion* and *matter*. These two seem the most distinct, if not the only conceptions of the mind, with regard to natural phenomena; and when we try to comprehend or explain affections of matter, which are not obviously modes of motion, we hypothetically or theoretically reduce them to it; the senses *perceive* the different effects of sound, light, heat, electricity, &c., but the mind appears capable of distinctly *conceiving* them

Digitized by Google

only as modes of motion. Does not this supply an argument that all physical agencies are reducible to these elements of mental conception?"*

Mr. Grove then shows how very probable it is that the pending contest between the contact and the chemical theorists, is, after all, merely a *disputatio verbi;* and he concludes his paper by suggesting for further inquiry, the investigation of the source of the sensible heat, which must become latent in the voltameter; and also whether it is the exact equivalent to the latent heat which must become sensible, in every cell of the series.

Postscript, July 7th.

Exp. 28.—By this time opportunity had occurred of repeating Experiment 7, with the closed cells, Fig. 3. The alternate tubes were filled with hydrogen and with water: action would continue, for a certain time, until all the oxygen from the water was exhausted, and then cease; when the stoppers were removed, so that the water could again absorb oxygen from the air, the action was renewed. Were it not for certain liabilities of error in manipulation, "the above would furnish an excellent method of examining the quantity of oxygen held in solution by water."

Exp. 29.—On repeating the eudiometric experiment (24) with the closed cell, it was found that, after the oxygen was abstracted from the atmospheric air and the water, *hydrogen* was evolved amongst the nitrogen: it was not due to the absence of atmospheric pressure; but its production required the exclusion of any notable quantity of air from solution, and great purity in the hydrogen; it led to the following plan of accurate eudiometry:—

"To use a battery similar to Fig. 3, but with tubes longer in proportion to their width; and, having first charged the tubes with hydrogen and atmospheric air, to allow these to remain in closed circuit until all the oxygen is abstracted and a little hydrogen added, by the electrolytic effect, to the residual nitrogen; then to substitute oxygen for the original hydrogen, which will in its turn abstract the hydrogen from the nitrogen, and leave only pure nitrogen."

An analysis of Protoxide and Deutoxide of nitrogen is effected by the same means.

Exp. 30, with hydrogen and carbonic acid, gave similar results, hydrogen being finally liberated by electrolysis into the carbonic acid; which shows that "the effect, therefore, is not due to any peculiarity of nitrogen; but yet some gas is necessary, for Experiment 28 proves that hydrogen alone will not decompose water."

Mr. Grove then describes an experiment with hydrogen and a vacuum. The following observations are made respecting the singular results of Experiments 29 and 30.

"That gaseous hydrogen should *abstract oxygen from hydrogen*, without the latter forming any other combination, is a fact so novel, that any attempted explanation is likely to prove premature. If, contrary to the views of Dalton, we suppose that gases, when mixed, are held together by a feeble chemical affinity, then we may say that the affinity of the nitrogen or carbonic acid for the hydrogen

* Vide Mr. Grove's Lectures at the London Institution in the present number of the Elec. Mag. p. 220.

Digitized by Google

produces the effect; the affinity of the oxygen of the water, being balanced between the hydrogen in the liquid and that in the tube, would enable the resultant feeble affinity of the nitrogen for hydrogen to prevail; but on this supposition, why does not oxygen produce an analogous effect? Its tendency directly to combine with platinum may indeed be regarded as an opposing force, but this tendency is by many considered hypothetical. On the other hand, it may be called an effect of contact; but this, unconnected with a chemical theory, presents no other idea to the mind than the fact itself presents; it furnishes no link by which we may extend the phenomena. I, therefore, until a better theory be found, should be inclined to adopt the former view, and to regard mixed gas as in a state of feeble chemical union. . . ."

Mr. Grove suggests, in conclusion, "that a longer time and more experience may give positive results, in cases where he has only obtained negative ones;" and that "it is far from impossible that, since curious solid combinations are formed by slow electrical currents, as in the experiments of Crosse and Becquérel, so novel gaseous or liquid products may be obtained by the long-continued voltaic action of gases and liquids."

The Bakerian Lecture. An Account of several new Instruments and Processes for determining the Constants of a Voltaic Circuit. By CHARLES WHEATSTONE, F.R.S, &c. Received June 15th. Read June 15th, 1843.

(ABSTRACT FROM PHIL. TRANS. PT. II. FOR 1843, p. 303.)

§ 1. THE object of this communication was to give an account of instruments and processes, which had been originally constructed in order to determine the practicability of telegraphic communication to great distances, but which had also been employed for investigating the laws of electric currents generally, and for obtaining the numerical values of the constants which enter into various voltaic circuits.

§ 2. As the instruments and processes are all founded on Ohm's mathematical theory, which is not yet generally understood and admitted, the author deems it necessary, in order that he may be understood, to give a short account of the principal results of this theory, which, for the vague notions of quantity and intensity, has substituted the clearer ideas of electro-motive force and resistance; and converted speculative conjecture into positive philosophy. ELECTRO-MOTIVE FORCE is defined as the cause which originates *current* in a closed, and *tension* in an unclosed circuit; and RESISTANCE, as the obstacle opposed to the passage of current, being the inverse, in fact, to conduction. When either the electro-motive force, or the resistance of any portion of the circuit varies, a correspondent degree of variation occurs throughout the circuit, "so that the same quantity of electricity always passes in the same instant of time, through every transverse section of the circuit." The FORCE OF A CURRENT, F, is in direct ratio to the sum of the

Digitized by Google

electro-motive forces, E, and in inverse ratio to the total resistance, R, so that $F = \frac{E}{R}$. The REDUCED LENGTH of a given wire, is a length exactly equivalent to the sum of the resistances in a circuit, R. If a proportionate variation is made in the electro-motive forces and the resistances, the force of the current remains the same; for $\frac{E}{R} = \frac{n\,E}{n\,R}$, so that the effect of *one* or of *many* similar elements is the same, provided no ***additional*** resistance, beyond the elements themselves, is interposed. But when an additional resistance is interposed, it will produce a far greater effect on the circuit of *one*, than on that of *many* elements, for its value being added to the denominator of each fraction, greatly alters their relative value. The following formula represents the resistance of a connecting wire included in the circuit of a series:

$$F = \frac{n\,E}{\frac{n\,R\,D}{S} + \frac{r\,l}{s}};$$

n, being the number of elements; R, the specific resistance of the exciting liquid; D, its thickness; S, the section of the plates; r, the specific resistance of the wire; l, its length; s, its section. Expressed in words we have the following laws:—

"The electro-motive force of a voltaic circuit varies with the number of the elements, and the nature of the metals and liquids, which constitute each element, but is in no degree dependent on the dimensions of any of their parts.

"The resistance of each element is directly proportional to the distance of the plates from each other in the liquid, and to the specific resistance of the liquid, and is also inversely proportional to the surface of the plates in contact with the liquid.

"The resistance of the connecting wire of the circuit is directly proportional to its length and to its specific resistance, and inversely proportional to its section."

The author then shows that, if a part of the current is diverted from a portion of the circuit, the force in each of the adjacent conductors, is in the inverse ratio to their *reduced lengths;* and that the *reduced length* of a single wire, which, when substituted, would not alter the force of the current obtained while the two wires were there, is in direct ratio to their *product*, and in inverse ratio to their *sum*. He gives formulæ for the force in the *undivided*, and for that in each of the two branches of the *divided* part of the circuit.

§ 3. The author here gives the definitions of several new terms, which the advance of the science has called for; and which are sanctioned by the authority of Ampère, who called the connecting wire a RHEO-PHORE, or current-carrier; and by that of Peclet, who, for galvanometer, substituted RHEO-METER, current-measurer. Mr. Wheatstone's terms are: RHEO-MOTOR, any apparatus which originates an electric current, whether thermo, or voltaic. Whence he calls a single pair a RHEO-MOTIVE element, and several pairs a

Digitized by Google

RHEO-MOTIVE series. He applies Peclet's word RHEO-METER, to all current measures, as galvanometers, voltameters, &c.; and suggests the distinctive terms, *Magnetic*, *Chemical*, *Calorific* Rheo-meter for the several particular constructions. RHEO-TOME, an instrument which interrupts a circuit; RHEO-TROPE, one which alternately inverts it; RHEO-SCOPE, an instrument to detect the existence of a current; RHEO-STAT, is applied to the instruments which form the chief subject of this paper, to be described in the sequel.

§ 4. The author then alludes to the method adopted by Fechner, Lenz, Pouillet, and others, for discovering the resistance of a circuit. They observed the force of the current, F, without any interposed resistance; and then the force F′, with a known interposed resistance.

$$F = \frac{E}{R} \quad F' = \frac{E}{R+r} \quad \therefore \quad \frac{F}{F'} = \frac{R+r}{R}; \text{ and } \therefore R = \frac{F'}{F-F'}\, r.$$

Although these are all known terms, there has been always great difficulty in obtaining the true value of the forces, F and F′ by the galvanometer. Fechner estimated them by the number of oscillations of the needle, when placed at right angles to the coil; others have obtained them by the deviations of the needle, the respective values of which had been previously determined. The practical objections to these methods are great.

The principle of Mr. Wheatstone's "method, is that of employing *variable*, instead of *constant* resistances, bringing thereby the currents in the circuits compared, to equality; and inferring, from the amount of the resistance, measured out between two deviations of the needle, the electro-motive forces and resistances of the circuit, according to the particular conditions of the experiment." For this purpose, he has contrived two instruments, which he terms RHEO-STATS, one applicable to *small*, the other to *considerable* resistances. Mr. Wheatstone here adds a note, in which he mentions that Prof. Jacobi had constructed an instrument similar in principle to his, but differing from them in mechanical construction; but of which no description had been published, in Aug. 1840, when the present instruments were shown to Jacobi. The instrument had been constructed for regulating the force of currents.*

§ 5. The RHEO-STAT, for considerable resistances, consists of two parallel cylinders, one brass, the other wood, with a spiral groove: a wire of small diameter, and of sufficient known length to fill the groove, is wound round the wooden cylinder, one of its ends being in contact with a spring, for connection with the *rheomotor*, the other end being fixed to the brass cylinder, a spring connecting the latter with the other termination of the *rheomotor*. Under these circumstances, the *whole* length of wire is included in the circuit; but as more or less of it is wound on the brass cylinder,—so does the effective part of the length vary. The

* For description of Jacobi's Instrumeut, Vide Proceed. Elec. Soc. p. 207, Jan. 18th. 1842.

Digitized by Google

dimensions usually employed are: the cylinders 6 inches in length, 1½ in diameter; 40 threads of the screw to an inch; and the wire is $\frac{1}{100}$ inch in diameter; it is thus thin, and is of badly conducting metal to increase the resistance. A scale is attached to register the number of coils included, and an index, on one of the cylinders, points out the parts of a coil. In experiment, this instrument, and a delicate galvanometer are included in the circuit. The author states the advantage of employing small elements in these researches, and describes one which he has found very constant in its action.

"The voltaic element consists of a glazed porcelain cell, 2 inches square, and 1½ inch high, in the centre of which is placed a small porous cylinder of earthenware or wood, filled with a liquid amalgam of zinc, the space between the two cells being charged with a solution of sulphate of copper; a slip of thin sheet copper bent round, and having one of its edges cut and turned over so that the wire of the circuit may be attached to it, or that it may dip into the amalgam of another similar cell, is placed in the solution. It will be seen that, in principle, this is but a slight modification of Prof. Daniell's constant battery, liquid amalgam of zinc being employed, as in Mr. Kemp's first experiment, instead of amalgamated zinc bars or plates, and the acid solution being dispensed with. This arrangement is, besides being constant in its action, extremely economical and easy to manipulate. Any negative metal may be substituted for copper, provided a solution of a salt of that metal be employed as the interposed liquid."

§ 6. The RHEO-STAT, for small resistances, is a grooved cylinder of wood, 10½ inches long, and 3¼ in diameter. A copper wire $\frac{1}{16}$ inch in diameter, occupies the groove, making 108 coils, one end of which is arranged for connection with the battery. Parallel to and above the cylinder, is a triangular metal bar, carrying a metal slide, the lower end of which presses against the spiral wire. As the cylinder is rotated in one or the other direction, the slide moves on; and the brass rod being in connection with the other end of the rheo-motor, more or less of the wire is included in the circuit. The galvanometer to be used with this form of the instrument, "must consist of a single thick plate or wire, making a single convolution."

The author mentions that—

"The rheo-stat, especially under the form last described, may be usefully employed as a regulator of a voltaic current, in order to maintain, for any required length of time, precisely the same degree of force, or to change it in any desired proportion. . . . . In volta-typing operations, the advantage of using the rheo-stat is obvious. By varying the rheo-stat from time to time so as to keep the needle of a galvanometer to the same point, a current of any required degree of energy may be maintained, without any notable increase or diminution, for any length of time: and, as the nature of the deposit, when the solution from which it is made remains the same, varies only with the force of the current, and the magnitude of the surface on which the metal is reduced, when once a good effect has been obtained, the same circumstances may be reproduced, with ease and certainty, and the effects of chance entirely eliminated."

§ 7. *Standard of Resistance.*—The unit of resistance, which Mr. Wheatstone takes, in all his experiments, is a copper wire a foot in length, and weighing 100 grs.; the diameter of such a wire is ·071 of an inch; and it is between the Nos. 15 and 16 of commerce.

§ 8. *The Resistance Coils.*—For measuring resistances beyond

Digitized by Google

the limits of the rheo-stat, an instrument is used, consisting of six coils of silk-covered copper wire, $\frac{1}{200}$ inch in diameter. The respective quantities are 50, 100, 200, 400, 800 feet. He has also another series of six coils, each containing 500 yards of the same wire. These admit of every degree of combination. The whole two series, when combined, and reduced to the equivalent resistance of the standard unit (§ 7.) give means of measuring resistances equal to 274½ miles.

§ 9. The resistance of a body interposed in a circuit is obtained by having a constant element, with a galvanometer and rheo-stat included with the body in the circuit; the body is then removed, and wire from the rheo-stat is added, until the needle gives the same deflection as at first. "The number of standard units, corresponding to this added length, will be the measnre." To determine the resistance of the galvanometer, when a second galvanometer is not at hand,—the galvanometer and rheo-stat are included in the circuit of a single element, and the deflection is noted; a second element exactly similar is now added, and the equivalent of the wire uncoiled, in order to reduce the needle to the same deviation is the measure of the resistance of the galvanometer wire + that of the connecting wires.

§ 10. *Process to ascertain the Sum of the Electro-motive forces in a Voltaic Circuit.*—The rheo-stat accomplishes this readily, without the need of proportionally graduated rheo-meters, or the tedious process of counting the oscillations of needles. The principle is as follows:—

"In two circuits, producing equal rheo-metric effects, the sum of the electromotive forces, divided by the sum of the resistances, is a constant quantity, *i. e.* $\frac{E}{R} = \frac{n\,E}{n\,R}$; if E and R be proportionately increased or decreased, F will obviously remain unchanged. Knowing, therefore, the proportion of the resistances in two circuits producing the same effect, we are able immediately to infer that of the electro-motive forces. But as it is difficult, in many cases, to determine the total resistance, consisting of the partial resistances of the rheo-motor itself, the galvanometer, the rheo-stat, &c., I have recourse to the following simple process. Increasing the resistance of the first circuit by a known quantity, r, the expression becomes $\frac{E}{R+r}$; in order that the effect in the second circuit may be rendered equal to this, it is evident that the added resistance must be multiplied by the same factor as that by which the electro-motive forces and original resistances are multiplied; for $\frac{E}{R+r} = \frac{n\,E}{n\,R+n\,r}$. The relations of the lengths of the added resistance, r and $n\,r$, which are known immediately, give, therefore, these of the electro-motive forces."

Practically, r and nr are obtained by adjusting things so that the needle shall point to 45°, and then noting the number of turns to be uncoiled, in order to bring the needle down to 40°; these for each combination reduced to the standard element give the relative forces.

§ 11.—(1.) That the electro-motive force of a large or a small element is the same, was shown by this mode of measurement. For the needle was reduced from 45° to 40° by thirty turns of the

Digitized by Google

rheo-stat; whether the small element already mentioned, (§ 5.) or one $3\frac{1}{2}$ in. by $2\frac{1}{2}$ diam., or one 6 in. by $3\frac{1}{2}$ diam. was used.

(2.) Five small elements of copper and zinc amalgam, charged with solutions of sulphate, ammonia sulphate, acetate, per-muriate and nitrate of copper, were examined. The first four, by requiring an equal number of turns (thirty), indicated equal electro-motive forces; but the force of the current of each differed according to their relative conductibility. The nitrate was inconstant from local action.

(3.) The direct ratio of the electro-motive force to the number of elements in series was shown by 1, 2, 3, 4, 5 elements respectively requiring 30, 61, 91, 120, 150 turns.

(4.) Voltaic reaction was measured by including a voltameter in the circuit. 3, 4, 5, and 6 elements were successively used; and when the number of turns, required in each case, were subtracted from the number corresponding with the electro-motive force of the respective series without the included voltameter, the average remainder was the same, viz. seventy turns. The reaction of the electrolyte to decomposition, compared with the electro-motive force of one element is therefore 7:3. "It is hence obvious why three such elements are necessary to decompose water in a cell with platina electrodes of a certain size, and charged with dilute sulphuric acid."

(5.) "The following measures will show the reduction in electro-motive force, of a zinc and copper, and of a zinc and platina element, by substituting dilute sulphuric acid for the metallic salt; the changes in these cases are effected by the adhesion of the hydrogen to the surface of the negative metal: —

Amalgam of zinc	Sulph. of copper	Copper	30	turns
,, ,,	Dilute Sulph. Acid..	,,	20	,,
,, ,,	Chloride of Platina..	Platina	40	,,
,, ,,	Dilute Sulph. Acid..	,,	27	,,

(6.) Experiments having shown no variation in the general effect, whether much or little zinc were present in the amalgam, the author was led to examine the electro-motive powers of the earthy and alkaline bases. He made a liquid amalgam of potassium, in the proportion of not more than two per cent., and obtained the following results:—

"Amalgam of Potassium....	Sulph. of Zinc....	Zinc	29	turns
,, ,,	Sulph. of Copper..	Copper ..	59	,,
,, ,,	Chloride of Platina	Platina ..	69	,,

"The third combination is one of great electro-motive energy; and, when a voltameter with small electrodes is interposed in the circuit, decomposes the water in it abundantly."

(7.) When the platinum plates were electrolytically covered with the peroxide of lead, or of manganese, the effects were further exalted:—

"Amalgam of Zinc	Dilute Sulph. Ac..	Perox. of Lead	68	turns
,, Potassium..	,,	,,	,,	98	,,
,, Zinc	,,	,,	Manganese	54	,,
,, Potassium..	,,	,,	,,	84	,,

Digitized by Google

(8.) Other experiments shewed that, of three metals in electromotive order, the force of the two extreme metals is equal to the sum of the forces of the adjacent metal; as—

"Amal. of Potass...	Sulph. of Zinc.....	Amal. of Zinc ..	29 turns
„ Zinc	„ Copper ..	Copper	30 „
„ Potass...	„	„	„	59 „

(9.) On comparing a thermo-electric pair, of bismuth and copper, with the standard voltaic element, the turns were 8 and 757, giving an electro-motive ratio of 1:94·6. Pouillet by a very different process had found it 1:95.

§ 12. In this section are given five methods of determining the resistance of the rheo-motor itself. As they cannot conveniently be abridged, we must refer our readers who are curious on this interesting subject, to the paper itself. Mr. Wheatstone found the resistance of one element of the arrangement, § 5, to be 2128 standard units. § 13. When once the resistance of a standard rheomotor has been found, other rheo-motors can readily be compared with it, by observing the number of turns + or − necessary, in each case, to cause the same deflection.

§ 14. *Instrument for Measuring the Resistance of Liquids.*

The author mentions the extreme importance of this branch of the subject, and that he is at present engaged in extensive experiments on the specific resistance of various liquids, of which he defers an account until they are completed; giving, for the present, merely the general plan on which they are conducted. He interposes $\frac{1}{4}$ of an inch of the liquid, with the rheo-stat and galvanometer, in the circuit, and observes the deflection. He then increases the liquid interval to $1\frac{1}{4}$, thus adding one inch; the reduced length of the quantity of wire wound, in order to give the same deflection, is the measure of the resistance of one inch of the liquid. The precautions requisite in these experiments, are mentioned. Another, but apparently less simple method, is also given.

§ 15. A simple means is given, by which one and the same *delicate* galvanometer may be employed to measure forces of every energy, and in all kinds of circuits.

"When the measures of energetic currents are required to be determined, by means of a delicate galvanometer, it is sufficient to attach its two ends to two points of the conducting wire. The distance between these points must remain the same in all comparative experiments, but the absolute deviations of the needle will be greater, as these points are further from each other."

The resistance of the galvanometer and of the reducing wire being known; and the division of the current being in inverse ratio to their resistances, the whole force may be estimated; care, however, being first taken to add resistance to the main wire, "in order to maintain the current the same as when no reducing wire

Digitized by Google

is added." If g be the reduced length of the galvanometer wire, and $n\,g$ that of the reducing wire, $\frac{g}{n+1}$ must be added.

§ 16. *The Differential Resistance Measurer.*

Three instruments for this purpose are described. The essential features of the first and second are two precisely similar circuits of wire connecting the poles of a rheo-motor, with a galvanometer so arranged, that the two precisely equal currents shall tend to pass through it in opposite directions, when there will obviously be no deflection. But if a small resistance (and these arrangements are specially contrived for small resistances), be interposed in one or other circuit, the corresponding disturbance in the normal direction of the needle of the galvanometer immediately ensues.

§ 17. The third form is in principle the same, but is adapted to the equilibrium between two currents from independent rheo-motors, instead of to diverted equal portions of the same current; and "can therefore only be safely employed when these are perfectly constant, or when the object is not to measure resistances, but to observe the comparative changes in two rheo-motors."

§ 18. This section developes the principle upon which the author has been able very readily to ascertain what degree of the galvanometric scale indicates half the intensity of another degree. The importance of this process forbids our abridging it:—

"If a wire of the same length, thickness, and conductibility as that of the galvanometer be placed so as to divert a portion of the current from it, it is obvious that one half of the current will pass through the galvanometer wire and the other half through the diverting path. Though it simplifies the consideration to suppose the extra wire to have the same length, diameter, and conducting power, it is easy to see that the same result follows if the two wires present the same resistance, which they do whenever $s'\,c'\,l = s\,c\,l'$. If the added wire produced no alteration in the intensity of the principal current, one half of the former force would act upon the galvanometer; but this is not the case; the addition of the wire produces the same effect as doubling the section of the galvanometer wire would do, and the total resistance of the circuit is, therefore, diminished. If the strength of the original current, when it passes wholly through the galvanometer $= \frac{E}{R+r}$ (r being the resistance of the galvanometer wire, and R, all the other resistances in the circuit,) $\frac{E}{R+\frac{r}{2}}$ will be the strength of the principal current, when the extra wire is added; if now an additional resistance $= \frac{r}{2}$, that is to say, a wire, whose resistance is equal to half that of the galvanometer wire, be added to the principal portion of the circuit, the intensity will be again $\frac{E}{R+\frac{r}{2}+\frac{r}{2}}$, and the force acting on the galvanometer, will be exactly half what it was at first."

The instrument, by means of which this principle is applied,

Digitized by Google

could not be well described without a drawing, we must, therefore, defer it to a future occasion.

§ 19. This valuable and very instructive paper concludes with some further observations on the process to determine the degrees of deviation of the needle of a galvanometer, corresponding to the degrees of force, and the converse; and its advantage over other methods are pointed out.

BRITISH ASSOCIATION.

Description of a Galvanometer. By J. P. Joule. Read 21st Aug. 1843.

'It is a well-established principle in electro-dynamics, that if a small magnetic needle be suspended in the centre of a coil or helix, and in the plane of its axis, the tangents of its deflections will be nearly, but not exactly, proportional to the quantity of current passing through the coil. It has, therefore, been found necessary to construct tables for turning the deflections of the needle into quantities of current. The necessity of forming these tables, was first insisted upon by M. Becquérel; and, in his "Treatis on Electricity," he has pointed out the laborious experimental processes employed by himself and others in their construction. It is obvious that one table would suit all instruments possessing the same relative proportions; and the instrument which Mr. Joule presented to the notice of the Association, was designed as a *type* for the construction of galvanometers. It consisted of a needle, three inches long, suspended in the centre of a coil, six inches in diameter. By a simple mechanical contrivance, the coil could be removed from the instrument, and replaced by others, adapted for the measurement of currents of different qualities and intensities; but in all cases their dimensions were to be exactly similar, and their diameter exactly twice the length of the needle. A most important part of the instrument was the needle, which was constructed on Dr. Scoresby's principle, and consisted of two straight and perfectly hard pieces of watch spring, placed at a distance from each other of about $\frac{3}{8}$ of an inch, the agate cap being fixed between them. The importance of this form of needle consisted in the facility it presented of constructing different needles perfectly similar to one another, with regard to the distribution of magnetism in them, which is essential to the accuracy of the same table applied to different instruments."—*Athenæum.*

On the Relative Electro-Negative Powers of Iodine and Fluorine. By Rev. J. Knox. Read 22nd Aug. 1843.

"The object of this paper was to controvert the statement made by Brande in his 'Chemistry,' that the fluorides are not decomposed

Digitized by Google

by chlorine or iodine; and to show, as the result of experiments, that fluorine has been erroneously placed above iodine as a negative element."—*Athenæum.*

On the Electricity of High-Pressure Steam; and a Description of a Hydro-Electric Machine. By W. Armstrong, Esq. Read 22nd Aug. 1843.

"This paper recapitulated all that has been done in this very interesting enquiry. The author assents to Dr. Faraday's opinion, that force with which the particles of water are rubbed against the glass, is, in this case, the cause of the developement of electricity."—*Athenæum.*

On the Regular Variation of the Direction and Intensity of the Earth's Magnetic Force. By Professor Lloyd. Read 21st Aug. 1843.

"In this communication, the author has given the principal results of the series of observations, which have been made at the Dublin Magnetical Observatory, as far as they have been yet reduced. These observations were commenced in the beginning of the year 1839, and have been continued, almost without interruption, to the present time. Since the beginning of the year 1840, they were taken every two hours, day and night, in accordance with the general plan of observation, laid down by the Royal Society. The elements directly observed are the *declination*, and the *two components* (horizontal and vertical) *of the intensity*; and from the variations of the latter, those of the *total intensity* and *inclination* are readily deduced. The means of observing the vertical component of the intensity having proved not altogether satisfactory, another instrument has since been contrived by the author, by which the changes of the inclination are given directly. Prof. Lloyd would not occupy the time of the meeting with any account of the instruments or methods of observation, which are now sufficiently known by all interested in the subject of terrestrial magnetism, but would proceed at once to the results obtained, so far as they related to the regular changes of the magnetic elements, commencing with the *diurnal changes*. These variations were projected in curves, which represented the course of the mean daily changes for the entire year, for the Summer and Winter half-years, and for each month separately.

"*Declination.*—The mean daily curve of the changes of declination for the entire year, exhibits a small easterly movement of the north end of the magnet during the morning hours, which reaches its maximum about 7 A.M. After that hour, the north end moves rapidly westward, and reaches its extreme westerly position at 1h. 10m. P.M. It then returns to the eastward, but less rapidly, the easterly deviation becoming a maximum about 10 P.M.;—the mean daily range =9·3 minutes. During the summer months, the morning

Digitized by Google

maximum at 7 A.M. is more marked; the evening maximum, on the contrary, disappears, there being a slow and regular movement of the north end to the eastward, from 7 P.M. until 7 A.M. In Winter, on the other hand, the evening maximum is well defined, and the morning maximum disappears, there being a slow and regular westerly movement, until 9 A M., after which the movement becomes more rapid in the same direction. The epoch of the extreme westerly position of the magnet is nearly the same throughout the year; the greatest daily range, in Summer, is about 13·7 minutes; the least range, in Winter, about 7·2 minutes.

"*Horizontal Intensity.*—The mean daily course of the horizontal force, for the entire year, has two maxima and two minima. The first minimum occurs between 1 A.M. and 3. A. M, or a little after. These fluctuations are small. A second and principal minimum takes place at 10h. 10m. A.M.; and a second or principal maximum, about 6 P.M.:—the mean daily range =·0024 of the whole intensity. In the Summer months, the smaller maximum and minimum disappear, the intensity decreasing continually throughout the night, but slowly, until 5 or 6 A.M. after which the decrease becomes rapid. There are, consequently, but one maximum and one minimum in the mean daily curve, which nearly correspond in epoch with the principal maximum and minimum of the curve for the entire year. In the Winter months, on the other hand, there are three maxima and three minima, the evening maximum appearing to break into two. The epoch of the morning maximum moves forward as the time approaches the Winter solstice, appearing to depend upon the hour of sunrise, which it precedes by a short interval. The epoch of the principal minimum is nearly constant throughout the year. The daily range is greatest in the month of July, when it is about ·0045 of the whole intensity; it is least in the month of January, being then about ·0008 of the whole.

"*Total Intensity and Inclination.*—The total intensity appears to vary very little throughout the day; it seems to be least about 9 A.M., and then to increase, attaining a double maximum in the afternoon. The total range, however, being very small, the variations of the two components of the intensity are dependent chiefly upon the changes of the inclination. The inclination is greatest between 10h. and 10h. 30m. A.M. and least about 6 P.M, the epochs corresponding with those of the least and greatest values of the horizontal intensity. The daily range is about two minutes in the early part of the year, and increases to more than double of that amount in Summer. If we combine the changes of declination and inclination, the former being multiplied by the cosine of the absolute inclination, we obtain the whole movement of the north-end of the magnet in free space, or the curve formed by the intersection of the magnetic axis with the sphere, whose radius=unity. The whole movement during the first six hours of the day is inconsiderable. It appears, on a review of these facts, that the diurnal changes in the direction of the magnetic force, are (as might be expected),

Digitized by Google

connected with the diurnal movement of the sun, and its times of rising and setting. The changes of the intensity appear to be influenced, in addition, by some other cause, or by the same cause operating less directly. Prof. Lloyd concluded his paper by an account of the annual changes in the magnetic force at Dublin, as far as they have been hitherto determined."—*Athenæum.*

Report on the Electro-Magnetic Meteorological Register.
By Prof. WHEATSTONE. Read, Aug. 22, 1843.

THE electro-magnetic meteorological register, constructed for the Observatory of the British Association, is nearly complete. It records the indications of the barometer, the thermometer, and the psychrometer every half-hour during day and night, and prints the results, in duplicate, on a sheet of paper, in figures. It requires no attention for a week, during which time it registers 1,008 observations. Five minutes are sufficient to prepare the machine for another week's work,—that is, to wind up the clock, to furnish the cylinders with fresh sheets of paper, and to recharge the small voltaic element. The range of each instrument is divided into 150 parts; that of the barometer comprises three inches; that of the thermometer includes all degrees of temperature between $-5°$ and $+95°$; and the psychrometer has an equal range. The machine consists essentially of two distinct parts: the first is a regulator clock, to which are attached all the requisite recurring movements; the second is a train, having an independent maintaining power, which is brought into action at irregular periods of time, by the contact of the plunging wires with the mercury of the instruments, as will be hereafter explained. The principal regularly recurring actions, connected with the clock train, are two:—1. The plungers are gradually and regularly raised in the tubes of the instruments during five minutes, and are allowed to descend during one minute. 2. A type-wheel, having at its circumference fifteen figures, is caused to advance a step every two seconds; while another type-wheel, having twelve spokes, but only ten figures, is caused to advance one step, when the former completes a revolution. The complete revolution of the second type-wheel is effected in six minutes, that is, in the same time occupied by the ascent and descent of the plungers. Thus every successive division of the range of an instrument corresponds with a different number presented by the two type-wheels, the same division always corresponding with the same number. The two blanks of the second type-wheel are presented during the return of the plungers, which occupies a minute, and during which time no observation is recorded. The breaking of the contact between the plunger and the mercury in an instrument, obviously takes place at a different position of the type-wheels, according as the mercury is at a different elevation; if, therefore, the types be caused to make an impression at this moment, the degree of elevation of the mercury

Digitized by Google

will be recorded. This end is thus effected. One end of a conducting wire is connected with the mercury in the tube of the instrument, and the other end with the brass frame of the clock, which is in metallic communication with the plunger. In the course of this circuit an electro-magnet and a single very small voltaic element are interposed. The electro-magnet is so placed as to act upon a small armature of soft iron connected with the detent of the second movement. So long as the plunger is in the mercury the armature remains attracted; but, at the moment the plunger leaves the mercury the attraction ceases, and the release of the detent causes a hammer to strike the types, and impress them, by means of black copying-paper on the cylinder. The armature subsequently remains unattracted until the plunger descends. Immediately before it reascends, a piece of mechanism connected with the clock movement, brings the armature into contact with the magnet, which remains there, in consequence of the recompletion of the circuit, until the contact is again broken.—*Athenæum*, Sept. 16.

Report of the Committee appointed to superintend the establishment of Meteorological Observations at the Kew Observatory. Read Aug. 22, 1843.

The limited funds at the disposal of the Committee have not allowed them to carry many of the contemplated objects into effect. The preliminary arrangements have, however, been completed, and a very perfect and efficient apparatus for making observations on the electricity of the atmosphere has been established. The Committee has paid more immediate attention to this subject, on account of its importance in connection with the system of simultaneous magnetic and meteorological observations now making on various points of the earth's surface, in the recommendation of which the Association has taken so prominent a part. The following is a brief notice of the present arrangements: — The dome, in which the equatorial was formerly placed, has been converted into the electrical observatory. A circular pedestal, about eight feet in height, is firmly fixed in the middle of the room, and a platform, which is ascended by a few steps, surrounds the pedestal, so that the operator, standing upon it, shall be at a convenient height to adjust and observe the various instruments. At the centre of the pedestal is fixed a strong glass pillar, supporting a vertical copper tube, tapering upwards; the length of this conductor is twenty feet, sixteen feet being elevated above the dome in the open air. The lower part of the conductor, within the dome, carries four horizontal branches, placed at right angles to each other; these are for the purpose of bringing into connection with the conductor the various electro-metrical instruments employed. The electricity of the atmosphere is collected by means of the flame of a lamp, kept constantly alight during night and day, and placed at the upper

Digitized by Google

extremity of the conductor; by this plan, which Volta recommended, much more electricity is collected, than by means of a metallic point. The lamp is lowered and elevated, when required, by means of a cord and pulley contained within the tube. The insulating glass support of the conductor has in its interior a hollow conical space, the base of which opens into the pedestal; beneath this opening is placed a small night lamp, which heats the air within the cone and raises the temperature of the glass pillar. The upper part of the external surface of this pillar is not sufficiently heated to prevent the deposition of moisture, and is therefore, to a certain degree, a conductor; the lower part also conducts slightly on account of its elevated temperature; but there is a zone between these two parts, which insulates perfectly, on account of the temperature of that part of the surface being sufficient to expel all moisture, and yet not sufficient to enable it to conduct. A conductor thus insulated will retain its charge for hours together without sensible diminution. Another peculiarity and advantage of this method of insulation is, that the active parts of all the electrometers are suspended from the conductor, and are, therefore, uniformly charged, depending for their insulation on the warm glass pillar only, and not, as usual, upon separate insulators, which dissipate the electricity unequally. Since the apparatus has been completed, the conductor has remained constantly charged, unless purposely discharged, or during the momentary transition from one electrical state to the other. The electric tensions vary in serene weather between $+3°$ and $+90°$, and the diurnal changes are indicated with great precision. This Report is accompanied by a sectional drawing of the Electrical Observatory, and by a Register of Observations commenced on July 1st, and continued regularly for six weeks.—*Athenæum*, Sept. 16th, 1843.

Report of the Committee appointed to conduct the co-operation of the British Association in the System of simultaneous Magnetical and Meteorological Observations. By Sir J. W. F. Herschel. Read Aug. 22, 1843.

The report commenced with referring to the proceedings of the Antarctic Expedition. Three seasons, in which the ships have forced their way at different points, far within the higher latitudes of the southern hemisphere, have furnished a magnetic survey of these regions equalling, or rather surpassing, both in completeness and accuracy, all those sanguine expectations which led the Association to urge on the Government the prosecution of this great enterprise. The magnetic observations of the Expedition which had been sent home, were in course of publication by the Royal Society. In the last of these contributions to terrestrial magnetism, the important subject of the corrections due to the iron of the ships is fully considered; and, by the aid of formulæ, furnished by Mr. Archibald Smith, of Trinity College, Cambridge, and founded

Digitized by Google

on the theory of M. Poisson, delivered in his Memoir of 1838 "Sur les déviations de la Boussole produites par le fer de Vaisseaux," the constant co-efficients of their corrections for each ship, are investigated. The corrections, deduced from these elements, are found to agree admirably with the results of the experiment, thus affording ground for the fullest confidence in the corrections depending on them, as well as in the theory from which they are derived, and in the general approximation to truth of the hypothesis necessarily made as to the distribution of the iron in the vessels. All the results being tabulated and projected in charts, the inspection of these gives room for the following interesting remarks:—1. As great discordances are to be looked for, and must frequently be experienced in magnetic surveys conducted on land, as in those at sea, and even greater. In effect, the chief and worst cases of discordance occur in observations made on islands. 2. The general form of the curves of higher inclination in the southern hemisphere is much more analagous to that in the northern, than appears in M. Gauss's maps. 3. Captain Ross's observations of intensity lead also to the conclusion of a much closer analogy between the two hemispheres than M. Gauss's maps would appear to indicate. No higher intensity than 2·1 has been anywhere observed. 4. In examining the observations of declination, particularly those which point out the course of the lines of 0^0 and 10^0 east, a more westerly position is indicated than that assigned by M. Gauss for the spot in which all the lines of declination unite. The Report then mentioned that the Government of the United States has assigned funds for a magnetic observatory at Washington, as well as for a further three years' continuance of that already established at Philadelphia. The Bavarian Government also has consented, on the application of the Royal Society, to maintain, for an additional three years, the Observatory of Munich. The first part of the volume of "Disturbance Observations" has been completed, comprising those made in 1840-41.* Colonel Sabine has prefaced this volume with a synoptic statement of the general conclusions, which it has been found practicable to deduce from the observations in their actual uncorrected state, of which conclusions the following is a brief outline:—At Toronto the march of the regular diurnal movements in declination does not consist in a simple uninterrupted progress and regress of the needle. Commencing from 2 P. M., its movement is continuous to the eastward till 10 P. M.; it then returns westward (through a comparatively small angle) until 2 A. M., when its eastward movement is resumed and continued till 8 A. M., after which its return is continuous to the west until 2 P. M. This second eastward progression is more decided in summer than in winter, and the total range of diurnal fluctuations is also more considerable. At Van Dieman's Land (a station, it is to be borne in mind, almost antipodal to Toronto), the course of diurnal oscillation agrees with that above stated in all

* Vide Review in the present Number of the *Elec. Mag.* p. 228.

Digitized by Google

but one feature, viz., that the hours (in mean time at the station) of easterly movement of the north end of the bar at the one station are those of its westerly movements at the other; that the diurnal range is nearly the same in both, with a similar inequality in its summer and winter amount; a similar alternate progression and recess also prevails, and at the same hours. These are certainly very remarkable features, showing a regular connection between two stations so remote, carried out into what may be regarded as minute particulars. Falling in, however, with the generally received impression of the universality of the causes (whatever they may be) which produce the periodical fluctuations of the magnetic elements, they can only be regarded as contributions to our knowledge of details. It is otherwise with the results deduced, by a comparison of the observations recorded in this volume, not only at these two stations, but also at St. Helena, with each other, and with those made by M. Kreil, at Prague, as respects cases of unusual magnetic disturbance which occur (so far as we can yet perceive) casually, or, at least, not periodically. Such comparison has enabled us, at length, unequivocally to state it as a general proposition, that the whole magnetic system of our globe is affected, in the majority of cases of great disturbance; for it is found that if a list of days of great disturbance, independently noticed as such, and marked by extra observations on each station, be made out, these lists will be found to coincide in at least a majority of days, and more especially in those days when the recorded disturbance has been greatest. Of twenty-nine principal disturbances recorded in Colonel Sabine's synoptic table, some confined to a single day, others running through two or three successive days, and comprehending altogether forty-nine days, by far the greater part are shown to have manifested themselves at Toronto, Van Diemen's Land, and Prague, and fifteen are marked by extra observations at St. Helena. But though it is thus rendered certain that the whole globe is affected in many and great magnetic storms, it is equally shown that the minute identity of particular shocks, which seemed to result from the earlier observations of this nature in Europe, is not in general traceable on anything like so extensive a scale. Not the least interesting part of this volume consists in the notices at Toronto of auroral phenomena accompanying the extraordinary magnetic disturbance; they are many and remarkable, and can hardly fail to throw great light on this branch of the present subject.* The difficult subject of the determination of the earth's magnetic force in absolute measure, has been subjected to a further investigation by Dr. Lloyd. The difficulty which it presents is of a practical rather than a theoretical nature, and arises from this, that the expression for the tangent of the angle of deflection of one magnet by another, involves co-efficients, which have to be determined in Gauss's method, by observations of deflection at two different distances and by elimination, in which process serious errors are introduced in the result

* See the list we have given page 229.

Digitized by Google

by small errors in the observations. The object of Dr. Lloyd has been to point out a method by which the quantity sought may be obtained without elimination by observations at one distance only, thus both diminishing the trouble of the observation, and increasing the accuracy of the result. This method depends on the assumption of an empirical law in the distribution of free magnetism in a magnetical bar, inferred by Biot from Coulomb's researches. Dr. Lloyd adduces several experiments confirmatory of these results. The Report next mentioned Lieut. Lefroy's intended course of magnetic survey in North America as far north as the Great Slave Lake. He crossed the line of no variation between La Cloche and Sault St. Marie, up to which point little change of dip had been experienced, his course leading nearly along the isoclinal line of 77°. The second series of Sir E. Belcher's observations, determining the magnetic elements of thirty-two stations (the two series embrace sixty-one stations) in the Pacific Ocean, the Indian and Chinese Seas, are now printed in the "Philosopical Transactions." —*Athenæum*, Sept. 16.

SOCIETY OF ARTS.

A Lecture on the Manufacture of Plated Goods to the Society of Arts. Delivered 19th April, 1843, by Mr. Frederick Potter.

This lecture comes within our province on account of the comparisons made in it between the old mode of plating and the electro-method; and we must premise that Mr. Potter, who is connected with one of the leading Sheffield houses, is a gentleman highly competent to express an opinion on the subject he has taken in hand; we shall refrain from animadverting on his observations, and shall let him speak for himself; and thus lay before electricians the practical objections which he perceives in the electro-method, and give them the opportunity of suggesting means by which they may be removed. After having described in detail the manufacture of plated goods, as conducted at the best houses, he said:—

"Many attempts have been made to apply the electrotype to the manufacture of plated goods, and as an assistant we may hope that that very beautiful discovery may ultimately be of service to the plater in the adaptation of ornaments, &c., where unusual relief is desirable; but as yet there appear to be great, if not insuperable difficulties to its general application.

"In the first place, the silver employed, or thrown down by the electro-process, is necessarily pure soft metal, without the alloy requisite to give it the tenacity and durability of standard silver.* Secondly, from the absence of silver

* And from its not undergoing the process of rolling and hammering, which tends considerably to render the metal hard, it is little calculated to stand attrition. Although by varying the strength of the current of electricity, or by other means, we are enabled to produce a harder deposite, yet, for the general run of articles, that would be less desirable than what is termed a regular [reguline?] deposite, from the fact of its becoming highly crystalline and brittle, added to which, it would become difficult to give such a surface the desired polish.

Digitized by Google

mountings, the exposed parts will be little suited to stand the friction of cleaning them.

"The electro-plating does not adhere equally on all metals; a local action seems to take place, as, for instance, on lead, and the union is equally incomplete in some particular alloys of metal. I here submit two plated candlesticks, the silver mounts of which had been worn through to the lead, which, on being re-plated by the patentee, on the electro-process, the leaden parts were not covered in the least by the silver. A spoon, made of some particular alloy of copper, nickel, and zinc, constituting a very inferior German silver, was plated several times by another electro-patentee, but the silver could never be made to adhere.

"There have been several attempts to replate worn-out Sheffield goods, and thus make them equal to new; but it may be doubted whether good sound articles would profit by such a process, even were the operation fully successful; ... but whatever may be its advantages, the specimens or attempts we have yet seen, are very far from successful.

"This pair of candlesticks, originally of strong Sheffield plating, had been in use for twenty years; they were re-plated by the electro-process about six months since; the order given to the patentee was that they should be well done, and the parties to whom they belong, mentioned that they intended them as a test of the method; they have been very carefully cleaned by an experienced person in the trade, and are already as bare as when sent to be re-plated. What makes this case the stronger is, that the candlesticks originally were plated upon copper only, having no silver mounts, and consequently no lead upon them; in fact, but a copper surface, to which metal the silver deposited by electric means adheres perhaps firmer than to any other. . . . .

"Upon the whole, the application of that highly interesting discovery, the electrotype seems far better calculated for producing clean, sharp, and accurate impressions of fine works of art than objects of utility, liable to strain or friction." . . . .

Mr. Potter concluded his lecture by reading a paper containing "the opinion of one of the most celebrated gilders of the day, on the comparative merits of the processes of gilding by electro and by mercury."

After confessing the deleterious effects of the "old mercurial mode of gilding," he adds:—

"The method proposed as a substitute is not without its evils. The auro-cyanide of potassium is the most available for the purposes of gilding; the cyanide of which is potassa saturated with prussic acid, so that the operator works in the vapour of an acid well known as a most deadly poison, the inhalation of the fumes of which after receiving the necessary heat, has an immediate tendency to depress the spirits and destroy the appetite; as the writer has experienced when experimenting by this mode. And, not being aware of the poisonous nature of the solution, his hands were much inflamed and swollen, with extreme soreness and pain, particularly on the tips of the fingers and under the nails, and from every little crack in the skin virus was discharged.

"Another point is the cohesion of the gold. By the electro-process, the deposite is not so fixed as by the old method. In proof thereof, take an article gilt by the new process, and subject it to a tarnishing heat, and the coating will be destroyed, whereas many things, gilt by the old process, have, in case of repair, been soldered, and the colour has been easily restored.

"Again; what is objected by some against the old mode, must, by all impartial and unprejudiced persons, be considered an advantage; viz., that by the electro-process we always get the one true and natural colour of unalloyed gold; but by the old process we obtain a variety. . . . The incomparable dead, such as we observe in French clocks, has not been approached by the new method; therefore, in this particular, the old mercurial process infinitely surpasses the new.

"In respect of the expense of the operation, it remains a question whether there is such a difference as to warrant a preference to the electro-process. The

Digitized by Google

solution, in the first instance, is very expensive, . . . and it is said that absolute inertness is a troublesome complaint, to which the solution is occasionally subject, and difficult of remedy."

The above extracts are taken from a printed copy of Mr. Potter's lecture; we lay them before our readers, because the hints thus gathered from the manufactory may be of avail in directing the operations in the laboratory. They contain the sum of the difficulties yet to be contended against in electro-chemical depositions; and so disclose to us the path which is still open for research. We must remember that an extreme view of the case is before us; and that experience does not fortunately magnify the evil. For instance, M. d'Arcet has removed the main objections which have been urged against electro-gilding;* and some such method as he describes may place plating on the same footing; so that, although there are certain difficulties, (and who will deny it?) in the electro-process, these may, in the end, be found not so serious as they at the present moment may appear.

Nov. 15.—A paper by Mr. F. Pellatt was read on the processes of electro-zincing and electro-coppering, to which we have previously alluded (Elec. Mag., No. 1, p. 74). After detailing the practical objections to other modes of applying zinc to iron, the author explained the advantage of electrolytic reduction; and his explanation was illustrated by many specimens of iron-work thus coated, among which was a hinge, which had lain,—as we ourselves had previously had an opportunity of witnessing,—exposed to the unfavourable atmosphere of the manufactory for many months; the coating was as sound as ever. The solution employed is one pound of sulphate of zinc to one gallon of water; which is of course electrolyzed by the battery process. In reply to a question, Mr. Pellatt stated that the expense of electro-zincing is about 3*d*. per square foot. Electro-coppering, which was described, especially in reference to iron, is, for obvious reasons, *commenced* by means of an alkaline solution; the ferro-cyanide of copper in the cyanide of potassium is found to answer best; it may be continued and finished with a sulphate solution. The adhesion between the copper and iron is described as being perfect. A case in point was given of a coppered bolt, which had been driven into a thick oak plank, and then withdrawn: this act of violence did not produce separation. The expense of electro-coppering was stated at about 8*d*. per square foot. The above processes are protected by patents granted to the Messrs. Elkingtons. We have in our possession several specimens of iron coated by the electro-process, which we intend subjecting to ordinary exposure, in order to test the durability of the coating. A favourable feature in the zincing process is that a rod of iron can be bent without cracking the zinc which covers it.

* Vide Elec. Mag., p. 98.

Digitized by Google

LONDON INSTITUTION.

Six Lectures on the Correlation of the Physical Forces. By W. R. Grove, Esq., M.A., F.R.S., Prof. of Exp. Phil. Lond. Inst. Nov. 13, 20, 27; Dec. 4, 11, and 18, 1843.

Mr. Grove has, in the present course of lectures, been specially anxious to direct attention to the several physical forces, viewed not one by one, and in the separate state, in which each presents itself to the attention, but viewed in their relation to each other. He uses the term correlation of forces as signifying a reciprocal dependence and mutual convertibility. This was the key note to all the lectures. He did not set out from any occult principle of causation as a starting point; but he took each force in order, and showed how all the others might be produced by it. The forces of nature, or, perhaps more correctly the convertional divisions of the effects of force, were described as *Motion, Chemical Affinity, Light and Heat, Electricity, Magnetism.* In the first lecture, he took *motion* as a source, whence the other forms might be derived. He showed that friction produces heat; but when anti-frictional arrangements are introduced, so that motion is carried off by motion, heat is not developed; that heat alone is generally the result of the friction of similar bodies; but that the friction of dissimilar bodies produces also, he felt bold to say, in *every* case, electricity. As a simple illustration of the conversion of motion into electricity, he instanced the spark from the prime conductor, which is, in truth, the result of the mechanical action of the hand by which the glass is moved before the rubber of the machine; and he alluded to the intimate association between these two forces by the fact that philosophers, without recognizing it, are in the constant habit of estimating the degree of charge by the amount of motion imparted, or motion produced, as when they say that a battery is charged with 50 turns of the machine; or that the electrometer is deflected 50°. In the succeeding lectures, each of the above forces was taken in turn as the source of the others, and the one principle put forth prominently throughout, was that, viewed abstractedly, neither one nor the other can be regarded as cause.

It would be out of place in us to give a detailed report of each lecture; nor is it necessary. The most striking experiments with which all of us are now familiar, together with several new ones, were progressively put forth in illustration of each position, as the several changes were rung on the above forces. In the case when *light* was taken as the prime generator, a very pleasing and comprehensive experiment was introduced. A prepared Daguerrean plate was so arranged, that any electric effect produced on it, could be instantly detected: under these circumstances, the moment light was allowed to impinge upon it, *chemical* action occurred, an *electric* current was elicited, and *magnetic* effects were produced. In the lecture which viewed *magnetism* as the source,

Digitized by Google

Mr. Grove stated his opinion that no magnet could attract more than its own weight from any, even the most limited distance; he had tested it by several very powerful magnets; and, indeed, if such attraction could be produced, there would be a creation of force.

The correlation of forces was not merely traced to the mutual production of each from either; but still more rigidly to the mutual relation, in respect to quantity; and it was urged most forcibly that no one of these forces could originate another of greater comparative value than itself. The importance of thus connecting the forces is obvious; it is a very great step towards restraining the mind from wandering in pursuit of some favourite theory into mazes which are impenetrable, and attempting to put asunder that which is eternally united, in the vain endeavour to sever *cause* from *effect*. Mr. Grove has shown a series of phenomena, many of which we have known long since; but he has so presented them, each in succession as cause, and as effect, to use the common acceptation of the words, that we are compelled to admit that it is false philosophy to regard any one as absolutely antecedent to any other. He is inclined to think that the farthest limit to which we can carry our ideas, when we attempt extreme generalization, is to view all natural phenomena as MATTER and MOTION; for, after all, our ideas must rest here. We may talk of light, or heat, or magnetism, or electricity, but we conceive them only as modes of motion; indeed, their existence is principally known to us by the effects of motion, associated with matter. A magnet, however powerful, might rest for ever unnoticed and unknown, unless, by some means, a piece of iron were *moved* within the sphere of its attractive power. So that, in fact, before we are ever in a condition to estimate the magnetic power, we are compelled to recognize a certain amount of mechanical power, or *motion*. These views will teach the electrician to receive with very great hesitation, any theories which would make electricity an *entity*, as matter; for, like all the other forces, (even that most abstract of all, *motion*, into which it can be converted,) we have only hitherto seen it as a property of matter. It has not been separated from matter, nor yet so associated with any part of matter, as to have a physical existence in a tangible form; and it is, therefore, to be taken, as it presents itself by its effects, without having consigned to it a place in the mind, which it is not entitled to occupy.

This, we fear, is but an indifferent and hasty notice of Mr. Grove's ideas: but we trust that enough has been said to impress our readers with a definite notion of the great and fundamental principle which that philosopher has endeavoured to inculcate.

Digitized by Google

REVIEWS AND NOTICES.

Magnetical Investigations. By the Rev. WILLIAM SCORESBY, D.D. Part I., 1839, p. 92. Part II., 1843, p. 360. With plates. Longman and Co.

THE welcome appearance of the second part of Dr. Scoresby's valuable Researches on Practical Magnetics, induces us to say a few words on the former part, even at the expence of repeating to our readers, things with which they are familiar. The first part comprises "Investigations on the Principles affecting the capacity and retentiveness of steel for the Magnetic condition; with the Development of Processes for determining the quality and degree of hardness of steel."

The Introductory chapter is followed by a description of two processes of Magnetization,—that for large bars being an improvement on Alpinus's well-known method,—that for thin plates being a modification of Knight's method. Each process includes the very essential condition of facility of manipulation.

The next chapter is one of very considerable importance, for on the accuracy of its contents depends the whole value of all the subsequent deductions; it contains a description of the means adopted to measure the power of the magnetized bars, and to convert this measurement into a numerical value. Comparative experiments are described; and the tangential deviation is the unit of measurement which is adopted. The important distinction between magnetic *capacity* and magnetic *tenacity* is very broadly stated in the fourth chapter; and a series of experiments are given, in which apparently similar bars or plates of steel are magnetized to saturation; and, after the magnetic value has been determined, are exposed to the demagnetizing action of a constant force, consisting of a powerful TEST-MAGNET. A result of very great practical importance is obtained from these experiments.

"In sets of bars or plates, constructed out of the same mass of steel, wrought by the same hand, and tempered, as may be supposed, precisely alike—the greatest differences will be found; such that, whilst some may sustain the loss of not more, perhaps, than one-sixth of their maximum power, others will lose the whole of their magnetism, or even have their poles reversed. Yet the manufacturer himself probably was not at all aware of the difference; nor could he, by any decided or satisfactory means, separate the good from the bad."

But the magnetic tenacity was all-influential in effecting that at which the artisan laboured in vain; by unerring evidence it classified the specimens operated on, into their respective groups. The next chapter is devoted to investigating, first, the magnetic capacity, and then the tenacity of four different kinds of steel, and five thicknesses of each kind; whence we have the relative value of each character of metal at various thicknesses. And here is seen a very leading fact,—that the magnetic value of a bar is in no degree proportionate to its mass; as, for instance, when the mag-

Digitized by Google

netic capacity of a bar is represented by 162, that of another bar, of eight times the mass, is only 341, instead of 1296. The softer the metal, the less its tenacity; which leads to a means of determining the relative *temper* of plates or bars of steel, by their relative tenacity; those which part with the larger portion of power being the softest; for the investigations show that "hardness and tenaciousness are co-relative." Then comes the more general application of the same magnetic test to determine the quality of steel in its raw state, and of the steel of which instruments and other manufactured articles are constructed. On this head, the author says:—

"Certain differences in the quality of steel, affect in a most striking manner, the magnetical properties of that substance; and that these differences in quality and magnetical properties may be available, not merely for ascertaining the degrees of carbonization, as they manifestly are, but, not improbably, for the determination of the essential quality of the steel, with relation to the quality of iron out of which it may have been manufactured. And, perhaps, it is not unreasonable to expect, that, were all the varieties of magnetic capacity in each denomination of steel, and in each quality, as respects the kind of iron out of which the steel is 'converted,' experimentally ascertained—that a strictly scientific process of testing, founded on these principles, might be devised; a process, which might, possibly, exhibit results, if not as exact, at least as conclusive, in certain most important relations of value in the metal, as are obtained by the beautiful process of assaying. And if so, even in a moderate degree of perfection only, it needeth not to say how important a contribution it might prove towards this great desideratum in the arts."

The last chapter contains some general inferences concerning the phenomena of magnetism. The author reverts also to facts developed in the early part of his researches, to which we have already adverted, when we spoke of the capacity not being in ratio to the mass; and he shows the practical advantage to be derived from comparative superior capacity of thin plates, by constructing magnets of a mass of previously magnetized thin plates.

The Second Part commences with a more close investigation of the powers of magnets thus built up; and the general result is, that although we thus obtain a more powerful magnet than we could have produced by magnetizing a single bar of similar mass, yet the combination does not by any means equal the sum of the constituent magnetic powers of each elementary bar. For several other results, bearing on this, our readers must consult the work itself. If, however, the elementary magnets be not in actual contact, the sum of the power is greatly increased, and the increase is greater in proportion to the thickness of the intervening non-magnetic medium. The ratio of gain thus acquired is very manifest in the higher combinations, especially of the harder qualities of metal.

In the course of investigating "The Relative Powers of Combinations of Magnetized Steel Plates or Bars, as affected by Differences in the degree of Hardness, or Nature of the Temper," a series of anomalous results presented themselves, which, at first sight, seemed in opposition to the general inference which had been drawn in favour of the superior magnetic value of hard over

Digitized by Google

soft steel. The value of the capacity and of the tenacity of twenty-four plates of tempered steel was taken singly and in groups; they were partially *softened*, and the power of each and of each combination *increased;* there was no error in the manipulation. But this apparent exception was found, by the application of careful analysis and rigid investigation, to be in fact a strong confirmation of a very general law; and, though it presented considerable embarrassment at the outset, it led, in the sequel, to a more clear and satisfactory comprehension of the subject. Having established the conditions under which this apparent exception exists, the author pursues his inquiry into the relative value of combinations of various temper, and proves, beyond dispute, that, however much combination of softer metal may be more powerful, in a very low series, yet when the series reaches even a limited extent, the very hardest metal is of the greatest avail.

We should have mentioned that the numerical values of the several series of results are projected in curves, so that the eye readily detects the relative powers of the single and combined bars, under the various circumstances to which they were exposed. By examining the curves which represent the values of the bars in the above experiment, it is interesting to trace the transition of superiority from one character of metal to the other, as the series varies: it is also instructive to notice the inferiority of the *very hard* plates in the low combinations, but the marked superiority as the series increases. But we have much matter before us, and must pass on.

The fourth, fifth, and sixth chapters are devoted to a very extensive and elaborate experimental investigation of the separate and combined powers of steel bars of different denominations and qualities,—of the magnetic powers of various combinations prepared for the needles of sea-compasses,—and the effect of annealing on the magnetic capacity and tenacity of hard steel. Nothing but extreme zeal and untiring perseverance could accomplish the very tedious and unattractive experiments with which these chapters are replete. Set after set of bars, character after character of steel, combination after combination, are examined with patience in the extreme; in the course of which, a vast mass of very valuable tabulated information, elsewhere projected, as before, in curves, is deduced. We may take a glance, and a glance only, at the general results. Among them it is found, "that *cast steel*, being capable (as it would seem) of the greatest hardness, is, as a denomination, the most effective in large straight bar magnets, whether consisting of single massive bars, or of considerable combinations of plates or bars." It appears too, that the *denomination*, or name, by which any given specimen of steel is known in the market is no key to its magnetic character; for the different quality or kind of iron, whence the steel is "converted" has a great influence on the result. Generally cast steel from the iron in best repute is best, although for single thin or medium plates, the cast steel from Bradford iron exhibits first-rate capabilities. By annealing hard steel

Digitized by Google

in hot oil, *thin* plates gain, but *thick* plates lose in magnetic capacity: several peculiarities belong to the ratio of this alteration, which cannot be entered into here. The magnetic tenacity of plates or bars of a straight or ruler form is always reduced by annealing. We will advert presently to the relative value of the various kinds and combinations of steel for compass needles, when we come to the practical applications of the principles deduced from the experiments,—suffice it here to remark, that, while the author has established distinctive characters to each specimen, he has shown how some gain and others lose by annealing,—how some are better for small needles, others for large,—and how some are better single, and others combined.

Some very curious effects come out in respect to bars bent in the horse-shoe form, which were very much the converse to the results obtained from straight bars; in fact, "The conditions requisite for highest energy in large masses, or powerful combinations, in magnets of the *straight bar form*, are, as respects the influence of extreme hardness, totally different in the case of magnets of the *horse-shoe form*;" and magnets in this form gain, when straight bars would lose by annealing.

The very many propositions which were necessarily derived from the peculiar character of these investigations, precluded a universal answer to the question,—Which is the best steel for magnetic needles? But the following general reply is given:—

"We should recommend, for all *large* or *massive* SINGLE MAGNETS of the straight bar form—the best *cast steel*, made quite hard: for STRAIGHT-BAR COMPOUND MAGNETS generally, the same steel and hardness; for compound magnets of any BUSK-PLATE description, the best cast steel, hardened to the utmost in oil; for HORSE-SHOE MAGNETS, if *single*, cast steel, annealed from file hardness, at a temperature of about 550°, or shear-steel a little reduced; and for COMPOUND HORSE-SHOE magnets, cast steel annealed at 480° to 500°, or shear-steel perfectly hard: for COMPASS-NEEDLES, if *single* and *heavy*, (such as are suited for stormy weather,) hard cast steel; if *light*, or of *moderate weight*, whether single or compound, best cast steel, annealed at 500° or 550°, or hard shear-steel, or hard cast steel from Bradford iron: and for VERY LIGHT NEEDLES, or other small magnets, the best cast steel annealed, as with advantage it may be, at the heat of boiling oil."

"In all these cases, the steel, whatever be the denomination, should be the produce of the best qualities of foreign iron, except in the instance of cast steel for compass needles of a light description, when steel from the best Bradford iron, might, it appears, be advantageously employed."

The author now arrives at a very important branch of practical magnetics, namely, the means of building up very large and very powerful magnetic batteries out of various combinations of smaller bars, not associated, as in all the cases which have preceded, merely as fasciculi, but subject to every system of groupment, which convenience might suggest. In order to ensure the efficiency of his measuring arrangements, now that they are to be applied to bars varying, instead of constant, in size, it was needful to subject the system of deviation, which he had hitherto employed, to a very rigorous examination. Having accomplished this to his own satisfaction, and to the satisfaction of others, who

Digitized by Google

had questioned the soundness of the method, he proceeds; and, so far as his inquiry has extended, he has demonstrated the possibility of associating magnets in proportional dimensions, so as to produce a power greatly exceeding any that has been hitherto obtained by mere magnetism. To this method he alluded before the British Association at Cork.* In reference to the celebrated magnet, constructed for the Royal Society by Dr. Knight, and known to us especially from its connection with Faraday's Magneto-Electric discoveries, its lifting power is stated to be 1200 or 1300 pounds, whereas, if constructed on the principles now laid down, it would carry upwards of a ton, or double the above weight.

The magnetic capacity of cast iron is very faithfully investigated, and several features of importance, among which are some which might not have been anticipated, present themselves, and they are such as may induce, occasionally, the substitution of this metal for steel in some combinations. We see, for instance,

"That in relation to steel, the magnetical properties of the best kinds of cast iron, are equal, if not greater, than those of *soft* cast steel in single, medium, or thick plates; and considerably superior to soft steel in large masses or in combinations of several plates.

"That cast iron of the best magnetical properties, such as No. 1., pig-metal, if cast very hard in thin bars or plates, appears to be capable, by combination, of forming as powerful magnets as, or even more powerful than, *solid massive bars* of ordinary steel, if only hardened slightly at the ends, or in the manner heretofore commonly adopted in the construction of magnets in this country."

The volume concludes with an exposition of the relative tenacity of several characters of steel, so far as the mere natural tendency to return to the normal condition is concerned, without the action of any extraneous force; or, if of any, of none other than the magnetism of the earth. A few general results are given; but this part of the investigation is necessarily very limited in extent.

The contents of these two volumes have been so replete with interest, that we have unwittingly been viewing them as it were abstractedly; we had almost forgotten the book and its author, while luxuriating in its very valuable details. We have devoted a long day to familiarising ourself with its contents; and only regret that we have to close it. But what a contrast is there in the easy means by which the reader gains possession of the practical facts included in its pages, and the untiring industry with which the patient philosopher must have steadily pursued the path of experiment, month after month, and year after year, in order to accumulate these details. The actual labour of mere manipulation, even though all things were prepared and at hand, is incalculable. If any class of investigation deserves peculiarly the commendation of philosophers, and the gratitude of a country, it is such as these, when a man, by years of self-denial and faithful investigation, prosecutes a series of most unattractive researches—as considered in themselves—utterly unconnected with any hopes of personal advantage, presenting them as a free gift to the world at large.

* Elec. Mag. page 137.

Digitized by Google

We must include in this notice an extract from the preface; and look forward with anxiety for the fulfilment of the promise it contains:—

"Besides the experimental inquiries of the first and second parts of these Magnetical Investigations, the author has always contemplated, if leisure and health should, in Providence, be yielded him, to extend the work to two or three additional parts, embracing, Practical Magnetics, with the application of these Investigations to the improvement of Magnetical Instruments and Apparatus; various original illustrations of, and experiments on, Magnetical Principles and Phenomena," &c. &c.

We should mention that Part II. is paged on from Part I., and the two parts will constitute a volume complete in itself.

The system of projecting numerical values into curves, which is adopted in this treatise, appears to be gaining ground; we have an instance in Professor Morse's paper in the present number of the *Electrical Magazine*. It possesses many advantages, for it places us in the condition for detecting the variation in the value of different arrangements, which the mere inspection of abstract numbers is not so calculated to furnish; it gives us, too, the power of comparing one series of experiments with another, and noting any marked stages of coincidence or the reverse.

Observations on Days of unusual Magnetic Disturbance, made at the British Colonial Magnetic Observatories, under the Departments of the Ordnance and Admiralty. Printed by the British Government, under the superintendence of Lieut.-Col. Edward Sabine, of the Royal Artillery. Part I., 1840—41. London: Published for Her Majesty's Stationery Office, by Longman and Co., 1843. Royal 4to., pp. 107.

For the advantage of comparing observations made simultaneously at various parts of the globe, during periods of magnetic disturbance, such observations have been selected from the general mass of daily observations, and published in a separate form. They will comprise the years 1840—45. The present part contains those of 1840—41. The places of observation are St. Helena, Toronto, Van Dieman's Island, and Cape of Good Hope. The present volume contains also the mean monthly positions of the magnets, at the regular hours of observation, in order that the regular may be eliminated from the irregular variations, leaving the residual portion to be traced to some of those disturbing causes, the precise character and influence of which, has not yet been determined.

We must not venture into the analysis of the tabular matter of the present publication, in the fear of being led beyond our limits. As the work will find a place in all electrical libraries, we shall content ourselves with extracting a passage from the preface, in which the Auroral influence over the needle is very obviously shown:—

"On examining the meteorological registers at the Toronto Observatory, with reference to the appearance of Aurora on the twenty-four days of principal mag-

Digitized by Google

netic disturbance at that station, it appears that on thirteen days of the twenty-four, the aurora was visible, and that, on the remaining eleven days, the sky was either densely overcast, or heavily clouded, so that the Aurora, though it might exist, could not be seen.

Jan. 18. Faint Auroral light.
.. 27. Auroral light in North.
Feb. 9. Densely overcast.
.. 23. Faint Auroral light.
Mar. 15. Bright Aurora.
.. 22. Generally overcast.
May 10. Densely clouded, with rain.
July 19. Bright Aurora.
.. 22. Heavily overcast, with thunder.
Aug. 16. Brilliant Aurora.
.. 23. Faint Aurora.
.. 26. Overcast, with haze.
Sep. 13. Aurora, with streamers and pulsations.
.. 21. Heavily clouded, with rain.
.. 25. Bright Aurora.
Oct. 9. Brilliant Aurora.
.. 25. Bright Aurora.
Nov. 5. Faint Auroral light.
.. 6. Densely clouded.
.. 11. Densely clouded, with rain.
.. 18. Brilliant Aurora.
Dec. 3. Densely clouded, with rain.
.. 14. Densely clouded.
.. 30. Overcast, with dense haze.

"The connection between Aurora and magnetic disturbance, each viewed as a local phenomenon, has often been remarked: the days in the above list, on which both occurred together, were, however, days of disturbance at Prague and Van Dieman's Island, as well as at Toronto; it would seem therefore, that we may view the occurrence of Aurora at Toronto, on these occasions, as a local manifestation connected with magnetic effects, which, whatever may have been their origin, probably prevailed on the same day over the whole surface of the globe."

Archives de l'Electricité, No. 10, tom. iii., 1843. Par M. A. De la Rive, Sep. 21, 1843. Pages 345—488, Plate. Glaser, Genève; Baillière, London.

This number has just reached us. It contains the papers by Becquérel, Faraday, Masson, and Bain, which will be found in the 1st and 2nd numbers of the *Electrical Magazine;* and M. Fargeaud's paper, which is now in the hands of our readers. There is a paper on the Conductibility of great Lengths of Wire, as employed for Telegraphs, by Professor Jacobi, which contains much practical information. There is a memoir on Induction and Electro-magnetism, by M. Batto. Amalgam of sodium, as employed by Henrici, and amalgam of potassium, as used by Mr. Wheatstone, are noticed. There are several other papers, among which is an account of some new Experiments on Induction, by Professor Henry. We may find some papers of importance sufficient to be translated into the pages of our next number.

Lectures on Electricity, comprising Galvanism, Magnetism, Electro-Magnetism, Magneto- and Thermo-Electricity. By Henry M. Noad. 1 vol. 8vo., wood-cuts, pp. 446. Knight and Sons, Foster Lane. New and enlarged edition.

In consequence of Mr. Noad's book having come to our hands at such a late moment, we must reserve for our next number a more detailed *review* of it. It would, indeed, be doing but poor justice to the author were we to attempt to say much upon it, until we had carefully gone through its pages; which, at this, the eleventh hour, we cannot do. We may, however, venture a few words on the *matter* of the volume before us, though we are

Digitized by Google

not now in a condition to speak of the *manner*. The course consists of *Nine* Lectures: the 1st, 2nd, and 3rd, comprise static electricity, and contain Faraday's Researches on Induction, &c., and also the "Phenomena of Atmospheric Electricity and the Action of Lightning Conductors." In glancing over the pages, the names of those who have recently written on these matters severally met our eye. The 4th, 5th, and 6th Lectures are on Voltaic Electricity, which is brought up to the present time; Animal Electricity is included in this division. The 7th is on Magnetism; the 8th on Electro-Magnetism; and the 9th on Magneto-Electricity and Thermo-Electricity. There is also an Appendix, in which are contained notices of certain discoveries which have occurred during the progress of the work. The author has been indefatigable in his exertions to render the work complete, if we may judge from the diligence he has displayed in collating the many valuable additions to the science, which late years have furnished. By the time the next number of the *Electrical Magazine* appears, our readers will be in possession of Mr. Noad's book, and they will then be able to go with us through its pages.

NEW BOOKS.

Smee's Electro-metallurgy, 2d Edition, 10*s*. 6*d*.—*Faraday's Experimental Researches. Series* 1 *to* 14, *with corrections and notes*, 18*s*.—*Becquérel's Electro-chimie, Appliquée aux Sciences Naturelles et aux Arts*, 7*s*. 6*d*.—*Walker's Electrotype Manipulation, Part I.* 13*th Edition*, 1*s*.—*Part II.* 7*th Edition*, 1*s*.—*Noad's Lectures on Electricity, new Edition*, 14*s*.—*Scoresby's Magnetical Investigations, Part II.* 10*s*. 6*d*.—*Harris on the Nature of Thunderstorms*, 10*s*. 6*d*.—*Dr. Bird's Natural Philosophy*, 12*s*. 6*d*.—*Glyphography*, 1*s*. 6*d*.—*Col. Sabine's Magnetic Observations, Part I.* (1840-41) 10*s*. 6*d*.—*Lardner's Electricity, Vol. II.* 6*s*.

NOTICES OF EXPERIMENTS.

A Remarkable Fulgurite.—"On the 13th of June, 1841, at 5 o'clock in the afternoon, a storm which ascended the course of the Elbe, passed over the sand hills, covered with vines, which exist on the right bank of the river, near the village of Loschwitz, at a league from Dresden, when a terrible flash of lightning struck the more elevated part of the vineyard called "Körnersche Wienberg:" the people ran to the top of the hill, thinking the lightning had struck the pavilion in which Schiller wrote his *Don Carlos*; but, fifty paces before reaching this building, they observed a vine-prop split, which indicated the place where the lightning fell. Mr. Fiedler, on being informed of this fact by the proprietor of the vineyard, first observed that the root which had been struck, was very near to a plum-tree, so tall that one might have expected it would have been struck in preference, for it was only 50 centimetres (20 inches) further on. Be this as it may, on following the trace at the foot of the rod, the fulgurite was observed to be buried at an angle of 66 degrees; it came amongst several small roots of the plum-tree, which it enveloped in its melted mass; but it did not follow the direction of these roots, although they con-

Digitized by Google

tained more moisture than the surrounding sand, and although their direction deviated very little from that of the electric spark. These roots, as may be seen in the specimen submitted to the Academy, are nearly blackened in the part embraced by the tubes, and in the portions immediately contiguous; the heat, although enormous, having been of too transient duration to carbonize the wood. At one mètre (39⅓ inches) from the upper part, the fulgurite is divided into three branches, each about 65 centimetres (25½ inches) long. We discovered on the spot that these roots were lost in a very moist bed of argillaceous and ferruginous sand." "This specimen, and that preserved in the Museum at Dresden, are the only two which may be considered as complete."—M. FIEDLER.—*Compte Rendu*, 31 *July*, 1843.

Fox's Galvanometer.—Mr. R. W. Fox exhibited an instrument for determining the relative intensities of electric currents. It consisted of a galvanometer in a box, the latter resting on a horizontal plate, to which it was attached by a central vertical point only, and could be turned in azimuth, on the plate; its angular position being denoted by a point or index attached to the box, and a graduated concentric circle on the horizontal plate, of rather greater diameter than the box. When used, the box and horizontal plate were both turned round, so as for the galvanometer needle and the index both to point at zero. The needle was then deflected by a voltaic current, and the box only was turned, till the needle again became stationary at zero. Its position with respect to the voltaic current passing through the helix, being then always constant, the size of the angle from zero marked by the index on the base circle, indicated the deflecting intensity of the current, in relation to that of any other current similarly tested; the intensity of different currents being directly as the sizes of these angles.

When the instrument is employed to ascertain the intensity of strong currents, and it is found needful to limit the amount of their deflections of the needle, a magnet attached to the box may be used for this purpose, or if preferred the method of torsion may be adopted, so that, by means of this apparatus, the electro-magnetic intensities of all such currents can be accurately compared.—10*th Report of R. Con. Polytech. Soc. p.* 25.

Electro-Cloth.—"Mr. Phillips has brought forward a plate for the negative element of a voltaic battery, which, being made of linen coated with copper [the linen having been rendered conducteous by means of plumbago], and afterwards silvered and platinized, afforded, from its greater roughness, a superior surface to that of the plates in common use."—*Cornwall Polytechnic Society*, 10th Report, 1842.

Patent Electro-Cloth.—Messrs. Elkington are coating cloth with copper for various purposes in the arts, as packing, roofing, &c. Instead of adopting the usual method of covering the surface with plumbago to impart conductibility, they paste the cloth on copper plates. The copper plates being made the cathode in a solution of sulphate of copper, the interstitial action of the metal avails to in-

Digitized by Google

duce a uniform deposit. Plating and gilding is introduced if required: the metallic cloth, when removed from the copper plates, is passed between rollers. The paste employed for this purpose is of a peculiar kind, the result only of actual experiment. Sometimes the single-cell process is adopted. The linen is then pasted on one side of an iron plate, the other side of which has been previously embedded in cement. The whole is then placed in the solution of sulphate of copper.

Substitute for Plumbago.—The *gradual* growth of electrotype metal over plumbagoed surfaces is, in many cases, a practical objection of considerable moment. Mr. Pellatt tells us (and we have to thank him for many practical hints of this kind), that they now use in Elkington's Manufactory, the following preparation.—Zinc is melted in a ladle until at the point of burning, when a few pieces of iron are dropped into it. When cold, the mixture is very friable. They reduce it to a fine powder, which is mixed with the plumbago, and apply as usual.

Steam-jets.—In pages 61 and 129, we described Faraday's experiments on the electricity developed during the escape of high-pressure steam. Fig. 1. is the steam-globe, in which he placed the water or oil, on which the character of the electricity depended. The steam passes out in the direction of the arrows. Fig. 2 is the cone apparatus, which is screwed on in the front of the jet, and is so constructed that the cone can be adjusted to afford greater or less resistance to the exit of the steam, as the case may be. Fig. 3 is the jet applied by Mr. Armstrong to the large hydro-electric machine, already described in these pages (p. 124). The arrow designates the path by which the steam passes out, so arranged as to exalt the degree of friction to which it is subjected; for the direction, by which it thus enters the small wooden cylinder, is eminently calculated to make it impinge most forcibly on the sides.

Fig. 1.

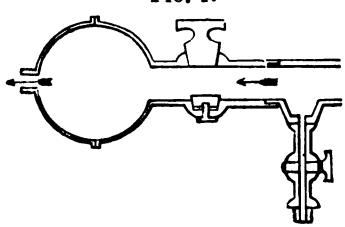


Fig. 2.

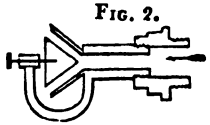
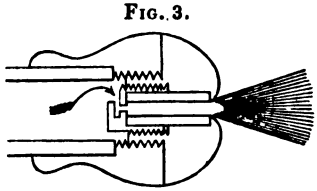


Fig. 3.



Application of Electricity to discover submerged Metals.—Lieut. Ramslett, of the Russian Navy, sinks a pair of insulated voltaic terminal wires in water suspected to contain metal. The respective ends of the two wires are so arranged, that if they come in contact with metal, the voltaic circuit shall be completed; if they do not, it, of course, will not. The test of the current is a galvanometer included in the circuit. By means of a magnetic needle

Digitized by Google

slided down, he discovers whether the metal present is iron or not. —*Lit. Gaz.* 21 *Oct.*, 1843.

Amalgam of Sodium for the Constant Battery.—M. Henrici prepared amalgam of sodium by plunging that metal into mercury, by which he formed a hard coherent mass. He substituted it for the zinc in a Daniell's arrangement; and compared the action with that of an ordinary constant combination. He says, "the action is so violent on the amalgam, that it lasts a very short time and is very irregular." The electro-motive force of such a combination is greatly superior to that in which amalgam of zinc is used.—*Archives de L'Electricité*, No. 10, Sept. 21, 1843. Davy's experiment on amalgams of the alkaline metals, as the positive elements of one-fluid batteries, will be found in the Philosophical Transactions for 1826, p. 408—[Ed.]

Magneto-electric Battery.—Mr. Wheatstone has lately constructed a magneto-electric battery, consisting of several machines, the helices of which are so combined that they form a continuous circuit, the current in one helix commencing before it has ceased in the others. It is especially applicable in cases where a great exterior resistance is to be overcome.—*Daniell's Introduction.*

The Carbon Battery.—A series of Bunsen's battery has been lately exhibited at the Adelaide Gallery, consisting of 80 cells. We were present at a private exhibition, but saw nothing in it to induce a belief that carbon will ever be practically valuable as a substitute for platinum in Grove's arrangement. The power did not nearly equal that of a similar series, arranged in the usual way. The essential mechanical adjustment of metal connections, between the consecutive zinc and carbon cylinders caused great local action, and reduction of power. After all, it is only a matter of original outlay, which is returned when the battery is no longer needed.

Plating and Gilding Medals of White Metal.—Mr. Tylee of Bath, by electrolyzing a solution of cyanide of copper, deposits a thin adhesive film of copper, which does not (and we speak from ocular evidence) in the least detract from the beauty of the medal. He now plates or gilds this.

Torpedo Occidentalis.—It appears, on further examination, that the specimen of Electric Ray, examined by Dr. Storer,* belongs to a hitherto undescribed species. He has, therefore, called it Torpedo Occidentalis, from its habitat, and has given a full description of it, illustrated by a plate. —*Silliman's Journal*, July, 1843.

Electrical means for obtaining Pure Hydrogen. — A means, often adopted in the laboratory, is to fill a platinum vessel with acid water, and invert in a similar liquid; and then to place on it a piece of zinc. The liberation of hydrogen immediately commences on all parts of the platinum, on the inside, as well as on the outside. The gas liberated within the vessel, of course, displaces the acid water, and thus, by electrolytic means, pure hydrogen may be readily obtained.—*Brande's Lectures*, Dec. 19, 1843.

* Vide Elec. Mag., No. 1., p. 74.

Digitized by Google

Lightning Conductors on the Royal Exchange.—The grasshopper, which has been so long celebrated as the Vane of the Royal Exchange, was elevated to the summit of the new spire, at 3 o'clock in the afternoon of December 8th, last past. It is of copper, and is 3 or 4 feet in length. We have erected from its back, immediately over the pivot on which it turns, a copper rod, three-fourths of an inch in diameter, slightly tapering, and terminated by a piece of platinum, as the commencement of a conducting train. We shall defer giving an account of the whole system until it is completed.—*Ed. Elec. Mag.*

Simple and Efficacious Diaphragm Battery.—In their practical applications of Electrotype, Messrs. Elkington are now in the habit of using the following arrangement. A plate of iron, having a connecting wire affixed to it, is laid on a flat table, and over it is poured a thick paste, of one part plaster of Paris and eight Roman cement. When the mixture begins to set, the plate is turned, aud the other side is coated in a similar manner. Iron thus embedded, is placed in a solution of sulphate of copper, and then forms the positive plate in a Daniell's arrangement; a copper plate being at times opposed to it; or, at other times, it is used as a single cell apparatus.

Electricity applied for Springing Mines.—The *Standard*, of Dec. 14, contains a very interesting letter by a Spanish officer, which is extracted from the *Espectador*. It bears the date of Nov. 26th. It appears that a deserter from Barcelona acquainted the officer with the fact that barrels of gunpowder were buried in the various approaches to the city, under the direction of a Belgian officer of Engineers. A party was privately despatched to ascertain the truth of the report, and 13 barrels of powder were exhumed. Each barrel contained a glass bottle filled with meal powder, among which was a cork, having two copper wires tied on either side, with their ends bent over the cork at right angles, so that the points, which were covered with solder, were about $\frac{1}{3}$th of an inch apart. The wires were covered with pitch; one of them was a very short length, and proceeded from the gunpowder into the earth; the other was carefully traced along a course of 500 yards, and led to a cellar in which was an electrical machine covered with straw. The machine was nothing more than a bottle mounted in a cigar-box, with a piece of bent stick for a handle. The cushion was a dirty doe-skin glove, with amalgam smeared on the palm; the prime conductor, an old tin snuff canister. The machine, to the surprise of the finders, was, in spite of its unfavourable locality, in good action; a spark was obtained directly on rotating it. The box was, in fact, provided with chloride of lime, the nature and utility of which they learned afterwards from a chemist. We can readily forgive the look of disgust with which the officer regarded this machine, and pardon him for being the first to call it "an infernal machine," and class its inventor with Fieschi and others, when we consider that, had he not made this discovery, one single discharge might have sprung the mine, and he and his soldiery might have

Digitized by Google

been in a moment destroyed; for every precaution was taken to ensure success.

Blasting by Magneto-Electricity.—Mr. Watkins has lately tried experiments, and has been successful in applying the current induced by magnetism to the ignition of gunpowder at considerable distances from the source of power. We mention this because it is new, and heretofore the ignition of wires by magneto-electricity has been usually produced in close vicinity to the armatures; and because the method may in some cases be more advantageous than the employment of the battery.

Chemical action of the radiation of Electrical Light.—Prof. Draper has described a "Tithonometer," or measurer of light, which can mark down effects, by movements over a graduated scale; it consists essentially of a mixture of equal measures of chloride and hydrogen gases, confined by a fluid in a graduated tube; the quantity of chemical action,—that is, the quantity of these gases, united by the action of a given light, is registered by the rise of liquid to supply the place of the gas. The following electrical experiment claims our attention:—

"Charge a Leyden phial, and place the tithonometer at a given distance from it, keeping the eye steadily fixed on the scale: discharge the jar, and the rays from the spark will be seen to exert a very powerful effect, the movement taking place, and ceasing in an instant.

"This remarkable experiment not only serves to prove the sensitiveness of the tithonometer, but also brings before us new views of the powers of that extraordinary agent, electricity. That energetic chemical efforts can thus be produced at a distance by an electric spark in its momentary passage, effects which are of a totally different kind from the common manifestations of electricity, is thus proved; these phenomena being distinct from those of induction or molecular movements taking place in the line of discharge, they are of a radiant character, and due to the emission of tithonicity; and we are led at once to infer that the well-known changes brought about by passing an electric spark through gaseous mixtures, as when oxygen and hydrogen are combined into water, or chlorine and hydrogen into muriatic acid, arise from a very different cause from those condensations and percussions by which they are often explained,—a cause far more purely chemical in its kind. If chlorine and hydrogen can be made to unite silently by an electric spark passing outside the vessel which contains them, at a distance of several inches, there is no difficulty in understanding why a similar effect should take place with a violent explosion, when the discharge is made through their midst; nor how a great many mixtures may be made to unite under the same treatment. A flash of lightning cannot take place, nor an electric spark be discharged, without chemical changes being brought about by the radiant matter emitted."—*Phil. Mag. Dec.* 1843.

Digitized by Google

ELECTRICAL MAGAZINE.

APRIL, 1844.

XXXIII. *On the Transport of Ponderable Matter, which occurs during Electrical Discharges.* By A. FUSINIERI.* From "Les Archives de l'Electricité," No. 11 and 12. December, 1843. Vol. III., p. 597.

(TRANSLATION.)

FIRST PART.

IF we expect to attain any certain datum as to the nature of the two electricities, we may best hope for success, by observations relating to the spark; for in it the two forces exist in a state of passage from one body to another, and in the most marked degree of isolation that can be attained. But such observations have hitherto been very incomplete, having been merely directed toward the form and colour which the spark assumes, according to the form and nature of the body whence it proceeds, and according to the nature of the medium which it traverses. Following the received ideas of the imponderable fluids, we are led to suppose that the spark consists in the passage of one or both these fluids between two bodies; and the question is, whether the heat and light, which are manifested, belong to these hypothetical fluids, or whether they are produced by the compression of the medium through which they pass,—a supposition which would leave these imaginary fluids absolutely cold and dark.

The last researches on this subject, of which I am aware,

* M. Fusinieri, in a memoir which he has recently published, has collated all the researches that he has made on the transport of ponderable matter by electrical discharges; he has added some new and interesting observations to those which he had already offered on this important point of electrical science. It occured to us, that, in order to give our readers a complete idea of the works of M. Fusinieri, we could not do better than give a literal reprint of the new memoir of the Italian philosopher. (DE LA RIVE.)

Digitized by Google

are those read by Davy, in 1821, before the Royal Society of London (*Ann. de Ch. et de Phys.* t. xx. p. 168), in which he shows that there exists a certain unknown relation between the form and colour of the spark and the medium which it traverses,—a fact of which proofs had been previously obtained. These researches were not made with a view of determining the intimate constitution of the spark; Davy admits the general opinion,—that of the existence of imponderable fluids; but he advances, at the same time, the opinion that these fluids may detach from bodies superficial particles, which produce, we scarcely know in what manner, the luminous appearances in vacuo.

There is nothing new in the fact that ponderable matter is transported, in infinitely small particles, by the electric forces; this fact has been known, although imperfectly, from the time of Muschenbrock (*Introd. ad Phil. Nat.* § 944); Brugnatelli announced in 1800, and again in 1808, the transport of metallic substances by means of electricity; but he did not explain that which it most concerns us to know, namely, the circumstances of the phenomenon (*Journ. de Chim. et de Phys.* 1808. Disc. prelim. p. 13). Finally Professor De la Rive, by many ingenious experiments, demonstrated the analogous fact, that the elements of decomposed substances are transported between the two poles of the battery, and that by moist conductors. He believes, moreover, that these elements have not the power of traversing metals (*Ann. de Ch. et de Phys.* 1825, t. xxviii.)

The experiments which I am about to describe, show that ponderable matter exists, although in a state of extraordinary division, in the electric spark of the ordinary machine;—that this matter is transported in opposite directions;—that it is in a state of fusion and incandescence;—and that, not only in the luminous, but even in the dark state, the electric force, in traversing dense and solid bodies, is accompanied by ponderable matter. It will then remain for us to examine whether we ought to attribute this force to other substances than ordinary bodies,—or rather whether sensible bodies possess of themselves the power of producing electric phenomena.

First Experiment.— I had long observed that, when we receive the positive discharge of a Leyden jar, having a brass knob communicating with the inner coating, upon a plate of polished silver connected with the discharging-rod, there is always manifested on the silver, at the point where the discharge takes place, a yellowish circular spot, of greater or less dimensions, according to the intensity of the discharge,—namely, of the diameter of one or two lines, and precisely of

Digitized by Google

the colour of brass. These spots, which are very faint, disappear after a certain time; the very fine film of brass, expanded on the silver, being volatilized.

In the middle of the yellow spots were constantly observed a group of little white points, appreciable to the microscope, which had altogether the appearance of oxide of zinc.

I concluded, from these facts, that the electric spark, from the ordinary machine, contains metal partly burned and partly melted, which is carried off from the surface whence the spark passes, and which is deposited, at least partially, on the surface into which it enters.

On repeating the experiment with a large Leyden jar, I further observed that, on the other surface of the silver, and at its point of contact with the brass knob of the discharging-rod, a little circular cavity was produced, in which it was evident that the silver had been melted. There had, therefore, happened, during the passage of the positive discharge from the silver to the discharging-rod, a contrary action and a reaction of the discharging-rod on the silver, by which the silver, while at the point of fusion, had undergone a pressure which had produced the cavity.

The following experiments were made with the electrical machine of the Lyceum of Vicenza. This machine, which consists of a glass cylinder, has all its metallic parts of brass; it is provided with two large glass jars, as Leyden jars, the coatings of which are of tin; the inner coating is connected with a rod, the brass knob of which rises above the vessel.

Second Experiment. — I formed a battery with the two large jars; and with the knob of one of them I connected a stout wire, terminated by a silver ball, which projected forward to the distance of a decimètre (4in.): I affixed to a glass handle a disc of copper thoroughly cleaned, 9 centimètres ($3\frac{1}{2}$in.) in diameter, and $\frac{3}{5}$ of a millimètre ($\frac{1}{40}$ in.) in thickness. The object of this arrangement was that I might pass the discharge from the silver ball to the discharging-rod, by the intervention of the copper disc.

When the battery was charged, I placed the copper disc in contact with the upper ball of the discharging-rod, and received on its other surface the discharge of the silver ball.

By thus operating, I constantly obtained the following results:—

1st.—On the surface of the copper which received the spark that came from the silver ball, there was a spot one or two lines wide, of a deep purple colour, produced by superficial oxidation. At the centre of this spot was perceived a slight cavity produced by the percussion, with a little greenish

Digitized by Google

brown spot, studded with infinitely small points of metallic silver.

2nd.—At the outer surface of the copper disc, and precisely at its point of contact with the ball of the discharging-rod, there appeared a little circular pit or cavity, in which was melted silver, that had assumed a greenish colour.

3rd.—On the brass ball of the discharging-rod, at its point of contact with the copper, there was a circular cavity, like that which has just been described; and which, in like manner, contained melted silver.

I must mention that the point on the front surface of the copper disc, where the silver ball was in contact with it, was not immediately opposite to the point on the back surface of the said disc, which was in contact with the ball of the discharging-rod; but that, between these two points, there was a distance of five, six, or even eight lines, according to the experiments; the silver, therefore, traversed this space, within the copper, without entering into alloy with it.

4th.—On the silver ball, whence the spark issued, were seen a collection of little black points, scattered about the boundaries and accumulated at the centre, which, beyond doubt, were formed of oxide of copper. These aggregations of oxide became more numerous in proportion as the experiment was repeated; the oxidized copper, therefore, was certainly carried in infinitely small molecules upon the silver, by a movement contrary to that of the positive discharge. These facts prove:—

That the electric spark, issuing from the silver, contained molecules of silver;—

That, scattering them about, it deposited a part of them on the surface, by which it penetrated into the copper;—

That the greater part of the silver, which was transported by the spark, penetrated into the copper, and there uniting into a single fasciculus, it traversed a considerable space in the copper without entering into alloy with that metal;—

That, this passage being accomplished, one portion of the silver remained deposited in the exit opening at the opposite surface;—

That another portion of the silver was transported upon the ball of the discharging-rod, which was in contact with the copper, after having traversed the latter in the same manner;—

That, while the silver was transported through the air, from the ball of this metal to the copper, an oxidized portion of copper was in like manner transported through the air, and was spread about upon the silver ball;—

Digitized by Google

That the existence of two opposed cavities, filled with silver at the points of contact between the copper and the discharging rod, situated one on the former, the other on the latter, but tinted with a greenish colour, proves that there was, at the point of contact, an action and a reaction,—a double mechanical pressure; and that a small quantity of oxidized brass was transported upon the silver, which came out from the copper.

Third Experiment.—Having charged the battery with the same apparatus, I placed the centre of the copper disc in contact with the silver ball, I received the spark on the other surface of the copper in such a manner that it should pass through the air, from the copper to the discharging rod. I constantly found—

1st. On the copper disc, at its point of contact with the silver ball, a little circular cavity containing melted silver, and surrounded with a small brown zone.

2nd. On the surface opposite to this, whence the spark issued, a slight cavity with a greenish spot, and some little specks of silver,—the whole perfectly resembling the results of the experiment which we have just described. (2nd Exp. § 2.)

3rd. On the silver ball of the battery, at its point of contact with the copper, a cavity where the silver appeared to be melted, but with an evident transport of copper into the whole of the cavity.

4th. On the brass ball of the discharging rod, a silvery spot, like that which existed on the surface of the copper whence the spark issued; and, in addition, several small brown spots studded with oxide of copper, and scattered about, as if the point of a needle had been applied to them.

In this case, then, there occurred a transport of silver upon the copper,—a transport in which the former penetrated into the latter by one of its surfaces, and, in a ramifying direction, then escaped by the other surface, diffusing itself with the sparks, partly arranging itself on this surface, and partly transported across the air to the discharging rod, when it arranged itself in a similar manner.

There was a transport of copper to the silver ball of the battery at the point of contact;—

There was, at this point of contact, a reciprocal action and reaction of pressure on the two metals, as is indicated by the two opposed cavities;—

There was a transport of molecules of copper, partially burned, to the brass ball of the discharging rod. They there produced so many cavities or impressions.—

There must have been, *vice versâ*, a similar transport of

Digitized by Google

burned molecules of brass, even to the copper, analagous with what took place in the second experiment, § 4. But they must have been confounded with the spot which the spark left on the copper. I could not discern them.

Fourth Experiment.—I substituted for the silver ball a gold ball of a centimètre and a-half ($\frac{1}{2}$ in.) in diameter, attached to a gold wire, which was connected with the brass knob of one of the jars, and which projected horizontally forwards about 7 centimètres ($2\frac{3}{4}$ in.) The wire being fine, the portion which did not touch the knob of the battery was contained in a small glass tube to prevent dispersion.

A well-cleaned silver disc, of the thickness of a sheet of paper, and about 9 centimètres ($3\frac{1}{2}$ in.) in diameter, was fixed to a glass handle. I formed one arm of the discharging rod with thick wire and a silver ball, similar to that which had been attached to the battery in the preceding experiment. The battery was composed of the same two large Leyden jars. When it was charged, I placed the centre of the silver disc in contact with the gold ball, and received the spark from the other surface of the disc upon the silver ball of the discharging rod.

With the apparatus thus arranged, I obtained the following effects:—

1st. On the silver surface, whence the spark issued, was instantly formed a beautiful gold spot, or a thin and continuous film of that metal. It was, in most instances, circular, and a centimètre or less in width. I sometimes obtained them larger, according to the intensity of the discharge.

The transverse distance between the centre of these spots and the point, where the other surface was in contact with the gold ball, was two, three, and even four centimètres. The gold, then, had traversed this distance in the silver, without mixing with it.

In the centre of the gold spot, a depression or slight cavity in the silver had become rough in consequence of superficial pressure. In addition to this depression, we could, by means of a lens, observe little spots, of a reddish brown colour, scattered around, and having the appearance of a metallic oxide.

These beautiful gold spots were, at the outset, very intense; but, at the end of a few minutes, they became fainter. Gold, reduced to this extreme degree of tenuity, easily volatilizes. The spots remained thus faint for some days, and they finally disappeared entirely.

2nd. On the other surface of the silver, and precisely at its point of contact with the gold, there was always a little circular cavity, surrounded with a brown zone, within which

Digitized by Google

it was evident that the silver had been melted, and where it presented a white and rough surface.

3rd. On the corresponding point of contact of the ball was a small depressed circle of silver, forming a slight cavity, and which had been melted.

4th. On the silver ball of the discharging rod were traces of a thin pellicle of gold. They were very slight, and soon disappeared. On the silver was a depression similar to that which was observed on the disc, at the point whence the spark issued (§ 1).

There was, therefore,—

Transport of gold through the silver to a distance of several centimètres;—

Expansion of the gold, after its passage through the silver toward the opposite surface, into so thin a film, that the metal has a tendency to volatilize;—

Contrary transport of the silver to the gold, at the point of contact;—

A film of oxidized metal, deposited by the spark in scattered molecules over the surface of the silver, whence it issued;—

Finally, mechanical percussion in opposite directions, either at the point of contact between the gold and silver, or in the passage of the spark through the air. In this case, the percussion sometimes took place on the silver disc, sometimes on the silver ball which determined the discharge.

Fifth Experiment.—I charged the battery with the same apparatus, and connected the silver disc with the silver ball of the discharging rod, and received the spark of the discharge from the gold ball upon the other surface of the disc.

I obtained the following results:

1st. A very thin film of gold appeared on the surface of the silver disc, which faced the gold and received the spark, as in Exp. 4, § 1. At the centre of this spot, there was a slight cavity with a commencement of fusion in the silver, and scattered around were reddish brown molecules of metallic oxide, precisely as was the case when the spark issued from the silver in contact with the gold.

It followed that the spark, which, according to the fourth experiment, issued from the silver in contact with the gold, produced at the surface by which it issued effects identical with those produced on the entering surface by the spark issuing from gold and received by silver.

2nd. On the other surface of the disc, at its point of contact with the silver ball of the discharging rod, a small cavity was visible, surrounded by a brown zone, and containing silver which had been melted.

3rd. On the corresponding point of the silver ball of the

Digitized by Google

discharging rod there was a similar cavity, and a similar fusion of silver.

4th. On the gold ball, which at the outset was very brilliant, after each experiment there were perceived, by means of a lens, a distinct aggregation of little salient points, evidently produced by a superficial fusion of the gold.

In this last case, I had no proof that the gold had traversed the silver, nor that the silver had been carried to the gold. I cannot altogether say that these phenomena did not take place. The transport of gold through silver, even after having first been transported by the spark through the air, is evident in the following experiment.

Sixth Experiment.—I placed the silver disc between the ball of the battery and that of the discharging rod, at an equal distance or nearly so; for the spark passed first from the gold ball to the disc, and then from the disc to the ball of the discharging rod.

The gold spot was evident on both surfaces. One portion of the gold was deposited by the spark in a thin film on the side at which the spark penetrated into the metal; and the other portion was, in like manner, deposited in a film on the surface by which the spark issued. The two spots were similar and about half the diameter of that which was produced with a charge of the same intensity, but on a single surface, in the 4th and 5th Exps.

Seventh Experiment.—I fixed the silver disc to one of the balls of a discharging rod, by means of a piece of wax, leaving a distance of about 1 millimètre ($\frac{1}{25}$ in.) between the two metals. A small opening pierced in the piece of wax permitted the discharge to pass from the silver to the discharging rod.

Under these circumstances, I received on the upper surface of the silver the ordinary spark issuing from the gold ball of the battery; and the results were the same as those described in the detail of the 5th Exp. § 1. But the very limited portion on the other surface, which corresponded to the hole (1 mill. diam.) pierced in the wax, was covered with a film of gold of a very decided yellow colour, which was not transient as in the preceding experiment. It became fainter at the end of several days, without entirely disappearing. The wax had prevented the gold, which had traversed the silver, from diffusing itself freely, so as to acquire a large surface; and there was formed a film twenty or thirty times thicker than the thin films, which, in the other experiments, volatilised.

I have hitherto said nothing in reference to what was going on at the ball of the discharging rod, which touched the outer coating, and at that portion of the coating. With regard to

Digitized by Google

the ball, I may mention that fresh molecules of tin were observed adhering to it; but with regard to the tin coating, its surface was not sufficiently smooth to permit of our discerning any new roughnesses, which might be manifested upon it. It is well known that in strong discharges the discharging rod slightly adheres to the outer coating. We may by analogy easily understand that, during this contact, an exchange of the two metals takes place, and also a mutual mechanical pressure.

I repeated, in the presence of Professor Magarotto, the 2d, 3rd, 5th and 6th Experiments; and he felt quite convinced of the real existence of a transport of silver through copper, of gold through silver, and of the formation of a deposit of these metals in thin films at the entering and issuing surfaces.

Second Part.

The first consequences which may be deduced from the facts, which have just been set forth, is that the electric spark of the ordinary machine is not composed of the pure fluid or the imponderable fluids which have been supposed to exist; and that its heat and light are neither qualities belonging to these fluids, nor effects of compression of the medium through which the spark passes—a compression which must be produced by these same imponderable fluids.

These hypotheses were merely substitutes for observation; but when facts prove that the spark contains molecules of these bodies infinitely divided, the division and chemical combination of which emit heat and light, there is no longer any need to recur to imaginary substances, and to compression, which cannot be conceived.

The sparks which occur between the two poles of a battery, either with metals or with charcoal, in like manner indicate the presence of finely divided ponderable matter in a state of combustion. At the sight of these sparks, every attentive observer very quickly perceives that they are nothing more than incandescent molecules. They are diffused, divided, radiant, and they affect the colours of the metals whence they proceed. After repeated scintillations, the metallic extremities are notably oxidized. The combustion of thin metallic leaf, when attentively observed, is nothing but a more extensive scintillation, repeated from spot to spot, along the whole extent of these little leaves, for they are not continuous.

The presence of air is the cause of two effects in the phenomena of the electric spark. In the first place, it prevents its free expansion into space; and, in the second place, it furnishes

Digitized by Google

oxygen for the combustion of the heated molecules. Hence it is that the spark in vacuo is more widely diffused; that is to say, that, instead of the spark, very divergent luminous appearances are obtained, which are due to the greater division of the ponderable matter, which contains within itself the principle of heat and that of light. In gases which contain no oxygen, the molecules of the spark must be in a state of incandescence, similar to that of which chemical experiments have demonstrated the existence, even without the concurrence of oxygen, in so many other combinations; or even without new combinations, by the mere division of parts.

Lightning itself leaves traces of ponderable matter, which accompany the odour it diffuses, and the carbonaceous and other traces which it imprints. Facts, hitherto unforeseen, might possibly be discovered, if these phenomena were observed, while the tendency of researches was in this direction. There cannot be any doubt raised against the presence of inflammable and even metallic substances in the air, the aggregation of which may explain the formation of aërolites,—a formation which is likewise attended with phenomena resembling electrical phenomena.

The experiments described in this memoir, show that matter is so inseparable from electricity, that it is present not only when this agent is in the state of spark, but also even when it is in the dark state; for it can traverse, in this manner, the densest of bodies, such as the metals; or to speak more fittingly, matter is itself animated with a real force which opens for it a passage through bodies, on the surface of which a portion of it is deposited, whilst the traversed body acquires the same force of spontaneous translation. From this it is evident that the mechanical effects of perforation, rupture, shivering, &c., are effects of the percussion of matter itself.

We need not be surprised that matter, when it has little weight, when it is divided into infinitely small particles and possesses a great elastic force, can produce great mechanical effects; because we are furnished with daily proofs in the air, in vapours, and especially in detonations.

In cases where matter is moved by the electric force, the velocity is immense; and it is a law of mechanics recently observed, that when the velocity is very great, the motion instead of being communicated from mass to mass, according to the known laws, produces a division in the parts of bodies. A disc of soft iron, rotated very rapidly, cuts hard steel;—it is well known that a candle, fired from a gun, can pierce a plank (*Bibl. Univ.*, Année 1825, t. xxix. p. 192). I would

Digitized by Google

ask of those who may feel some scruple in admitting that great mechanical effects may be produced by matter possessing little weight, if they imagine that they find a greater mass in the imponderable fluids, the existence of which they admit.

In order to be justified in saying that electric forces consist of two imponderable fluids distinct from the matter, which is evident to our senses, we ought to find them isolated from this matter; and if they are not isolated, even in the electric spark, where then will they be so?

Third Part.

I believe from the results of the numerous researches which I published in 1821 and 1823,—results confirmed by other observations upon the combinations of gaseous substances by the operation of the surfaces of solid bodies, published in 1824 and 1825,—I say, that I believe there exists in all matter a force or principle of action, in virtue of which, when matter is reduced to dimensions of extreme tenuity, a repulsion is developed among its particles, which gives them a tendency to divide spontaneously and progressively according to determinate laws, and always, consequently, with a greater development of the same action.

I have found that this force acts essentially in chemical combinations by virtue of effects, which we call *capillary*; and it is from its being also the source of heat, that I have named it *native caloric*. It is especially abundant in substances, which give a powerful manifestation of the opposite electricities under the action of the voltaic pile; and, for this reason, I have regarded it as being the common principle of the two electricities. It must not, however, be confounded with these two agents, for it produces numerous effects which are not electrical; and hence classes of phenomena, which are very distinct, must not be confounded under a single denomination.

I may call to mind three principal facts, which, in the results of the experiments above-mentioned, have led me to recognize the existence of this force in the bosom of matter;—

The first fact is that of the diffusion of infinitely small ponderable molecules in the electric spark. This is not an effect of the resistance of the air; for the diffusion is still more marked in a space deprived of air; it is a spontaneous effect of matter when in a very finely divided state,—an effect, which results from the proper force it possesses of dividing and subdividing progressively.

Digitized by Google

The second fact is that of the expansion of brass and gold (Vide Exps. 1, 4, 5 & 6), on the polished surfaces of the silver plate, in films so fine that they go off in vapour. One of the principal effects of the force in question is to extend the substances, in which it is manifested, into thin films, wherever a fair surface is offered, upon which this extension may take place. I see then in that volatilization, acquired by brass and gold, when reduced to extreme tenuity, another effect of the same force; for gold, in greater dimensions, is not volatile; the little film in the last experiment, (Exp. 7.) ceased being so, simply because it was twenty or thirty times thicker than the others.

I have observed that silver, even though it were transportod like gold, did not extend so readily on copper, as gold did even on the silver surface. The silver spot, which was always very contracted, and of which I have spoken in the preceding experiments, was most visible immediately after the discharge: after a short time, there only remained the specks of silver, which I have also mentioned. I attributed this difference to the lower degree of polish of the copper discs; the force of expansion is always reduced if it encounters a rough surface or other obstacles.

In fine, I have found a proof in favour of the expansive force proper to matter, in the pressure in contrary directions, which the experiments have constantly presented, whether in the passage of the matter through a metal in contact with another, or in its passage between two metals through the air in the state of incandescence or spark. To act in all directions, and consequently to act in two directions only, when the others are denied it, is a property of finely divided matter when endowed with an expansive force; I conceive, for example, that silver, in a state of fusion, assumes the cylindrical form, in consequence of the lateral obstacles with which it meets during its expansion; the expansive force of this cylinder will act along its axis in two contrary directions.

I consider the electric spark to be composed of ponderable matter, so attenuated and divided, that each molecule is possessed of that force which tends to subdivide it progressively and indefinitely; its diffusion, therefore, is greater as the space is more extended.

With regard to the heat and light of the spark, I believe that both proceed from the same molecules, and that they depend on the same force; but that the emission of heat and light is greater when the molecules undergo some chemical combination, in which the same force always acts.

Finally: concerning the two electrical states, positive and

Digitized by Google

negative, I believe that they are two modifications, at present not understood, of the same active principle; or a mode of action in two opposite directions, according to a law as yet unknown. In order to arrive at more exact knowledge on this point, observations must be multiplied, and those especially which relate to phenomena in detail must not be cast aside.

Note by M. De la Rive.—We shall not stay to discuss the theoretical ideas with which the author terminates the memoir, that we have now given. There are, undoubtedly, among these ideas certain points of view, the justness of which we are the first to recognize. Thus, it is perfectly true that we have never as yet separated the electricity in any form from the bodies by which it is manifested; and, as M. Fusinieri observes, in the phenomena even of the spark, there is ponderable matter with the electricity. It is also true that there exists in matter an expansive force or tendency, which is in many cases the cause of very extraordinary phenomena. But, in our opinion, M. Fusinieri goes too far, or at least quite too *fast*, when he entirely denies the existence of imponderable agents, even to the explanation of luminous or calorific phenomena. It is possible that the progress of science may one day lead to this result; but we must remember that as yet it is very far from it; and that a greater accumulation of experiments, of a more perfect character than we at present possess, are needed, before we can attain this point. (A.)

XXXIV. *Petrina on the Influence of Flame upon Frictional Electricity.* From "Poggendorff's Annalen," Vol. LVI., p. 459. Translated and communicated by W. G. Lettsom, Esq.

(TRANSLATION.)

Among the numerous experiments upon this subject, which I have instituted since November 1841, I will here cite those only which, in my opinion, offer the most interest to the cultivators of this branch of science.

1. Having electrified, either positively or negatively, a pair of pith balls, hanging free in the air, it will be observed that they instantly close, on approaching to them, in any direction, a flame of any kind, or even in passing it before them, as rapidly as one will, at the distance of a few inches.

2. An insulated, highly electrified metallic ball, loses so much of its electricity by passing a flame before it, that it will scarcely affect any longer a sensitive electroscope.

Digitized by Google

3. In the vicinity of a flame, or of an iron ball at a white heat, neither positive nor negative electricity can be communicated to a pair of pith balls; and this in whatever direction the body, which is rendered electrical by friction, or by any other means, is brought near to them.

4. On bringing near to the top of a gold-leaf, or of a straw electrometer, on one side the flame of a taper, and on the other side an electrified body, acting on the electrometer by induction, though not so powerfully as to make it strike the sides, and then slowly removing both the flame and the electrified body, (taking away the former somewhat before the latter,) it will be seen that the electrometer has acquired a certain charge of that electricity possessed by the body brought near to it.

5. A cylinder, which is rendered electric by induction, becomes electrified with an opposite or a similar electricity to that of the inducing body, according as a taper has been brought for an instant close to the end turned away from the experimenter or that presented to him, and then removed beyond the sphere of its action.

6. The influence of flame upon an electrified body is suspended by any solid substance that is placed between them, be it ever so thin, and whether it be a good or bad conductor of electricity; for instance, wood, paper, glass, thin metal plates, and so forth.

7. The flame of a taper in ordinary circumstances, when tested by as sensitive an electroscope as we please, gives no trace of electricity; but, if the air surrounding the flame is somewhat electrical,—if, for instance, experiments in frictional electricity have been carried on in the room, the flame immediately indicates the electrical state of the air which the room contains, inasmuch as it charges an electroscope brought near it. By employing for this experiment Bohnenberger's electroscope, provided with a good condenser, we can, with that instrument and the flame of a taper, discover the slightest amount of electrical tension in the air.

8. If we place a lighted candle on the conductor of an electrical machine, it does not become charged, for the electricity is dispersed in every direction, by the action of the flame. In a little while, after about twenty turns of my weak machine, I found the air, in the whole room, in an electrical state; sixty turns sufficed for my tracing electrical tension in the air of a second, and indeed of a third room, at the distance of fifty feet. The doors of the second and third rooms must be open, when we wish that the air therein should be rendered electrical; and no tall objects should stand in the way; for, in the neigh-

Digitized by Google

bourhood of the walls or insulated objects, the air, even in the first room, is not electrical. It is not, however, necessary that the machine should stand opposite to the door.

9. When, in the preceding experiment, a lighted taper is placed in the room, the electrical state of which we propose to examine, the effect is all the stronger.

10. Flame discharges a Leyden jar, charged either with positive or negative electricity, when it is brought, together with the candle, into the circuit; and this without noise or spark, and in a very short time.

11. A Leyden jar of a square foot external coating can be charged, by means of the flame of a taper, at a considerable distance from the machine, and without being in any way connected with it. For this experiment, the flame of a taper is to be so placed as to touch the knob of the jar. The jar being then placed some feet away from the machine, and other objects removed, the outer coating is to be put in connection with the ground. On putting the machine in motion the jar will become charged. In performing this experiment, it is advisable to remove the flame from the knob of the jar before stopping the machine, otherwise it exerts an action in discharging it. With my weak machine, at a distance of four feet, the jar receives a very considerable charge; at six feet distance, the charge is strong; at eight, a spark is obtained; and at twelve, I obtained decided traces of a charge.

The cause of this action of flame is not founded, as we might easily be led to suppose, upon the motion of the air brought about by the process of combustion; for a pair of pith balls, repelling each other, do not collapse, however rapid may be the motion we give them through the air, or when we produce a current in the air surrounding them, by means of a pair of bellows. Neither is the action attributable to heat; for the balls do not fall together, on being brought as close as possible to a heated stove, be it as hot as it may, and however long they may be left there: neither are they affected by an iron ball, at a low red heat, being brought near them. Nor does light appear to be the cause of this action; for the balls do not collapse either in the direct light of the sun, nor in the focus of a lens or a mirror. What follows renders it abundantly evident that the action is not due to the effect of points. A system of more than sixty needles let into a conducting base cannot discharge a pair of pith balls, excited with either positive or negative electricity. If we charge a jar with negative electricity, and adapt points to its knob, and there being near to these a pair of pith balls that repel each other by a charge

Digitized by Google

of the same kind of electricity, the balls are repelled by the points, and do not collapse, the jar being either insulated or not. If the knob of the jar is, however, provided with the flame of a taper, the balls lose their charge on being brought near it, and fall together. From all the experiments instituted upon this point, I think I am justified in inferring that the phenomenon in question is attributable to the process of combustion. Oxygen appears only in a determinate electrical condition (perhaps that of zero) to enter into chemical combination, and to assume and maintain that condition to a considerable distance from the point of combination, and thus to conduct off the superfluous electricity with which it was perhaps charged; or, in case it was negative, to attract what is wanting from a distance. Although many not unimportant inferences might be drawn from the above, for the sake of brevity I abstain from entering upon them at present.

Extract from a Note from Mr. Weekes to Mr. Noad.

"A friend at Washington has given me the particulars of a remarkable experiment in frictional electricity, translated by him from a paper by Petrina of Linz. Last night (10th November, 1843), about eleven o'clock, the wind being east, a beautiful and uniform current set in from my atmospheric apparatus, and lasted nearly two hours. This enabled me, (probably for the first time under such circumstances,) to try the experiment with signal success. Petrina's experiment consists in charging a jar of a foot square external coating from a plate machine of about thirty inches in diameter, by means of the inductive power of the flame of a candle,—the flame being brought in contact with the knob of the jar, the coating of which was in communication with the earth, but placed at the distance of six or eight feet from the machine, instead of being in contact, or nearly so, with the prime conductor. It is advisable to remove the flame from the knob of the jar before ceasing to turn the machine, otherwise the flame subsequently acts the part of a discharger. Petrina says, he obtained distinct indications of a charge at the distance of twelve feet from the machine. In my experiment last night, by means of an atmospheric current and a two-gallon jar, the knob of which was placed in contact with the flame of a tallow candle (six to the pound), fourteen feet removed from the terminus of my apparatus, *seven spontaneous discharges took place within four minutes.*"—*Noad's Lectures on Electricity*, p. 442.

Digitized by Google

XXXV. *Second Memoir on the Colouration of Metals.* By M. Becquerel. From "Les Comptes Rendus," Feb. 5, 1844. No. 6.

(TRANSLATION.)

Preliminary.

Since the two communications,* which I had the honour of making to the Academy, touching the colouration of metals by means of successive deposits of the per-oxide of lead, through the agency of voltaic electricity, I have been engaged in multiplying experiments so that I might trace the causes of the effects which are produced, and find processes, which should be the most simple and at the same time the most practical, by aid of which uniform and durable tints might be obtained on objects of various forms and of any metal, in order that the artisan might be readily enabled to adopt this new art. The results, to which I have arrived, and which are contained in the memoir, that I have now the honour of presenting to the Academy, attain, at least, I am bold enough to hope that they attain the end which I had in view; for I have not omitted any practical details, which are essential to enlighten the artisan, and to put him in the condition of being certain of the success of his operations.

The phenomenon of electro-chemical colouration, produced on metallic surfaces, is the same as that of thin films covering the surfaces of certain bodies, and by their transparency exposing to view the same surfaces with colours, the character and the brilliancy of which depend on the thickness of the films that are deposited, and on the colours of the body itself; and which often present to the eye the brilliant phenomenon of coloured rings.

Nobili was the first to describe the production of coloured rings on metallic plates, by means of deposits produced by voltaic electricity,—phenomena, which are analogous to those obtained long since by Priestley with successive discharges of electrical batteries: the English philosopher had observed that, on transmitting several successive discharges of this kind with a metallic point to a metal plate, there were produced on the plate several series of coloured rings, which were the same whatever the direction of the discharge might be; that is, whether the positive electricity left the point or the plate. The necessary conclusion was that the colour depended on a cause acting equally in each direction. The experiments

* Vide Elec. Mag. No. 2, p. 85 et seq.

Digitized by Google

having at first been made on copper and on steel, — metals which acquire colour as they cool, after having been exposed to the action of a degree of heat equal to that which occurs during the discharge, the obvious belief was that this was the cause of the production of the coloured rings. But, as they were afterwards obtained in like manner on platinum and on gold, the transport of the very matter from the point was necessarily admitted,—which matter, by being deposited upon the plate in films, that were thinner as they were farther from the central point, gave rise to the coloured rings;—a conjecture, which was changed into a certainty after M. Fusinieri's experiments respecting the transport of matter through metallic substances by the effect of discharges, whatever be their direction.*

In order to convey a distinct idea of the phenomena first described by Priestley, and afterwards studied with further developments by Nobili, who employed voltaic electricity, and to compare them with those about to be the subject of the following memoir, I will relate the principal results, which were obtained by these two philosophers.

When a plate of metal is subjected to a succession of discharges from an electrical battery, by means of a point, also metallic, the colour of the plate, even to a considerable distance round the central spot, is changed; and the entire space is covered with a certain number of concentric rings, each of which presents the beautiful colours of the spectrum. The nearer the point is to the plate, the sooner do the colours appear, and the closer are the rings compacted: if the distance is excessively small, the colours appear at the first discharge; but then they are confused.

The number of the rings increases in proportion to the fineness of the point; the more blunt it is, the wider are the rings; but, at the same time, their number is less. Upon a steel plate, for a given distance, the colours around the central spot, are not immediately evident; an obscure red zone is first observed; then, after five or six discharges, by looking at the surface obliquely, a circular space is visible, either slightly shaded, or tinged with an extremely faint red colour, which gradually is filled with rings of all colours, the borders of which become brown, if the discharges are continued beyond the first annular space, which was originally defined by a slight shade, and which is the first tint of the paler colours, that are developed around the brownish red, constituting the interior surface. The most decided tints are first seen around the central spot, and recede, as the explosions are repeated,

* Vide Elec. Mag. p. 235.

Digitized by Google

in order to give place to new colours, which recur after thirty or forty discharges. There are three rings exceedingly distinct. On continuing, the coloured rings become less beautiful and less clear, in consequence of the red predominating, and more or less tarnishing the other colours.

The rings, which are deposited, adhere so firmly that a feather, or even the moist finger does not alter them at all; they may, however, be removed with the nail. The interior rings offer the greatest resistance; nevertheless, as will be evident, *they cannot resist a slight amount of rubbing*.

When the discharges are too violent and steel is being operated on, the surface becomes corroded; and erosions are produced, which destroy the distinctness of the effects that are produced. These erosions do not occur on polished silver, tin and bronze. Coloured rings, as well as their attendant effects just described, are obtained on gold, silver, copper, bronze, iron, lead and tin; and are always obtained, whatever be the direction of the discharge.

To obtain the coloured rings by means of voltaic electricity, the current proceeding from one of the poles of the battery must be concentrated, as was first effected by Nobili, in a platinum wire, the point only of which is immersed in the liquid to be decomposed, whilst the other pole is connected with a plate of metal contained in the same liquid. This plate is placed perpendicularly to the direction of the wire, and about 1 millimètre from its point. The effects produced depend on the nature of the metal plate, on its positive or negative state, and on the nature of the solution. They are easily obtained, and in a few seconds, with a battery of the ordinary construction.

Nobili, by experimenting upon a great number of solutions, with a platinum wire, and plates of platinum, gold, silver, tin, bismuth, copper, brass, &c., obtained very various results, the principal of which I will mention.

Solution of Sulphate of Copper.

Silver plate positive.—Four or five concentric circles, alternately clear and obscure.

Silver plate negative.—Three small concentric circles: the largest and the smallest of a deep red, the intermediate circle of a clearer tint.

Brass plate positive.—Slight traces of five concentric circles of the colour of brass, some clearer, others less so, and thus alternating with each other.

Brass plate negative.— Circles of two shades of metallic copper alternate, as upon the silver.

Digitized by Google

Solution of Sulphate of Zinc.

Silver plate positive. — Obscure spot in the centre, distinct yellow circle, then a circle of light blue, and finally a beautiful zone verging to yellow.

Brass plate positive—Five small circles derived from the copper liberated by the action of the current, and presenting two alternate tints, the one distinct, the other dull.

Solution of Sulphate of Manganese.

Silver plate positive.—Five concentric circles alternately distinct and deep, the fifth more distinct than the others, and surrounded with a halo of a pale yellow, which merges into a violet-tint. These circles are analogous to those obtained with the sulphate of copper.

Solution of Acetate of Lead.

Gold and platinum plates positive.—Concentric iris, composed of rings originating one from the other, and propagating in the manner of waves.

Silver plate positive.—Iris less distinct than on gold or platinum.

Solution of Acetate of Copper.

Platinum, gold and silver plates positive.—Nothing worthy of remark.

Same plates negative.—With silver, for example, often four concentric circles, which, when exposed to air, acquire the following tints: deep blue at the centre, then yellowish red, blue of a less deep tint, and yellowish red, presenting a different shade from that of the second tint.

Solution of Acetate of Potassa.

Silver plate positive.—A circle within three others, of 1 centimètre in diameter, surrounded with a very brilliant silver belt, which is succeeded by a faint halo of different colours.

Analogous results have been obtained by Nobili, with many other solutions, and especially with liquid extracts of organic bodies, such as the juices of carrot, onion, parsley, garlic, horse-radish root, cabbage, celery-leaves, beet-root. The effects obtained with these liquids are so curious that I must quote some of them.

Carrot Juice.

Silver plate positive. — Dark centre surrounded by two circles, the one yellowish, the other greenish, then different zones strongly coloured.

Digitized by Google

Horse-radish Juice.

Silver positive.—At the centre a dark point, around it a small white circle; a greenish zone, terminated by a blue circle; then one or two circles of a beautiful gold yellow, and finally several very feeble coloured rings.

Beet-root Juice.

Silver positive.—At the centre a red point surrounded by four circles, the first yellow, the second blue, the third red, and the fourth green, further on two or three beautiful coloured rings.

Nobili drew the following conclusions from these experiments:—

1st.—*There exists a difference between the mode of action of the two poles, relative to the faculty which they possess of becoming covered with matter*, the positive pole being greatly superior to the negative, especially with regard to organic matter.

2nd.—In general the effect of the negative pole is augmented by operating with a more intense current, or else by adding to the metallic salts, a salt with an alkaline base.

The same philosopher had thought it might be that the coloured effects, which he had obtained, were due to deposits of thin films; but he gave no account of the nature of these deposits. For example, in relating what happens with a mixture of the two acetates of copper and lead, he adds (*Annales de Chim. et de Phys.* Serie 2, t. xxxiv. p. 287):—

"But if the coloured rings are derived, as may be the case, from some of the electro-negative substances of the solution, which are deposited in thin films on the surface of these two metals, why does not the same happen with other metals? This question is possibly worthy of exercising the sagacity of chemists."

Such are the general results obtained, on the one hand by Priestley, and on the other by Nobili, during their experiments on the production of coloured rings by means of electricity; and I thought it right to relate them, in order to make known the state of the question concerning colouration, when I took it up in a different point of view to these two philosophers. I will return to these results, after having explained those, which form the subject of this memoir.

In order to colour metals by the method indicated in my first memoir, and described more in detail in the *Elements d'Electro-Chimie*, which I have recently published, I employ an alkaline solution of lead, in which the oxide acts as the electro-

Digitized by Google

negative element. I may repeat, in a few words, the mode of experimenting:—the solution is placed in a glass vessel, in which there is an unglazed porcelain cylinder filled with nitric acid; the object to be coloured is plunged into the solution, and a platinum plate into the acid; the object is connected with the positive pole of a decomposing apparatus formed of several elements, and the platinum plate with the negative pole; the porous vessel and the nitric acid may be dispensed with,—and this is the easier plan,—and the platinum plate may be plunged in the alkaline solution. As soon as connection is made, the surface of the object is covered with a succession of thin films of the peroxide of lead, which produce the effects of colouration. The adhesion of these films is as great as that of gold on copper in gilding, because the protoxide of lead, which passes to the state of peroxide by the reaction of the oxygen of the water, and the gold are respectively liberated at that pole, which corresponds to the part that each of these bodies plays in the solution. The deposit of peroxide may, therefore, be brought about as regularly on the positive surface as that of gold on the negative, when all the conditions given in the sequel are attended to.

On the Composition of the Liquor.

The alkaline solution must be completely saturated with the oxide of lead, otherwise the deposited films of peroxide will not fail to dissolve in the alkali, as soon as the current ceases to pass, or even when there is merely a reduction in its chemical action. It is necessary then, when it has been used, to boil it from time to time in a flask with excess of litharge, and as much out of contact of air as possible, to prevent the potash absorbing carbonic acid. When it has been used for a long time, and consequently contains carbonate of potash, it must be boiled with caustic lime; the carbonate of lime which is formed must be allowed to settle, and, if necessary, it must be filtered, or the clear part of the solution may be decanted into a suitable vessel. This solution must give 24 or 25 degrees of Baumé's areometer; for experiment has proved that this density was the most suitable to produce the best effects. When not in use, it is placed in a carefully corked flask.

The temperature of the liquor must be moderate, that is, must not exceed 12 or 15 degrees.

The success of the operation depends on the good composition of the liquor, on its density, on its temperature, and, especially, as we shall mention in the sequel, on the intensity of the current and the perfect cleanliness of the

Digitized by Google

articles. This operation is as essential for the perfect colouration of metals, as for electro-chemical or for water-gilding. The presence of fat bodies, or other non-conducting substances on the metallic surfaces, renders this perfect cleaning necessary.

On the Preparation of the Surfaces.

I have already said that the films of peroxide of lead, which are deposited, being transparent, allow the surface of the objects to be seen. Consequently, as is the surface of the objects, so is their aspect, or rather such is the brilliancy of the colours. Whence it is essential, in the outset, to give them the required state, that is, the burnish or the matt, according as brilliant or dead colours are desired. Suppose we are operating on polished plates of gold, gilt copper, or platina; we begin by rubbing them with a soft brush, and water slightly alkaline; they are then washed in abundance of water. In case the adhesion of foreign matters is too strong to admit of their removal by these means, the plates are rubbed with a brush covered with English rouge, then with a brush and alkaline water, and they are then washed in abundance of water. Articles, which were at first inactive, are then seen to become covered readily with the richest colours. These different preparations are especially necessary, when articles are experimented on a second time after the colours have been removed; for deposits often remain, which interfere with the brilliancy of the colours, or even oppose all further deposit. The articles being prepared, touching them with the fingers must be avoided; for their mark is indicated by an absence of deposit, or simply by a deposit of a bad character. The greatest precaution must, therefore, be taken, in attaching the conducting wires; so that it is necessary to hold the objects with a piece of linen that has not touched any organic matter capable of adhering to the surface. On a good preparation depends, I repeat it, the success of the operation.

Other modes must be adopted with copper, iron, and oxidable metals, which, on account of their oxidation, are not always suited to receive such beautiful and varied colours as gold, gilt copper and platina.

For copper objects, they must in the outset undergo a first cleaning, by heating the articles to redness and then immediately plunging them into dilute sulphuric acid, indicating 12 degrees on the areometer, and the temperature of which is 60 or 80 degrees. Pickling is then commenced, by plunging them first into nitric acid, and then into a mixture of nitric and sulphuric acids, in the proportion of three of the former

Digitized by Google

to one of the latter, with the addition of a little sea-salt. Soot* is to be avoided, as it might deposit fatty matters. The articles are then washed in abundance of water, and plunged immediately into the alkaline bath, without being dried by saw-dust, — an operation, which is not without its inconveniences, on account of the foreign bodies, which might be deposited on the surfaces.

The articles, after having been cleaned, may indeed remain for some short time in the water, out of the influence of the air; however, they must not be suffered too long, for fear of alteration.

When the copper has been well cleaned with what is called the buff-stick (*brillant* Fr.) very satisfactory effects of colouration are obtained; but they do not approach those given by the burnish and polish, especially the former, which gives a vigour of tone, that cannot be obtained after mere pickling; but, in this case, the operation even of polishing and burnishing introduces on the surfaces foreign bodies, which must be removed by washing them as above, not with a brush and an aqueous solution of potash, but with very fine linen steeped in alcohol which has a little potash in solution; — they must then be washed in abundance of water.

Whenever the pieces of copper or brass, and principally the latter, are but of small dimensions,—about 2 or 3 centimètres square, the colouration assumes the same phases as on gilt surfaces of small or of large extent; but, when the dimensions are considerable, the surface remains brilliant for a longer or shorter time, and seems to be in a passive state, like that of iron, which has been plunged into concentrated nitric acid; in this case there is no colouring effect. Whence then is the origin of this passive state of brass, when in connection with the positive pole of a voltaic apparatus? Is it due either to the formation of an oxide of copper, which is consequently opposed to that of the anhydrous per-oxide, or rather because the plombate of potash is simply decomposed? These are questions to which it was our duty to allude, while speaking of the state of surfaces, but which cannot be investigated, until I shall speak of colouration. There is a certain sign by which we can immediately recognize that the deposit will not take place, namely, when abundance of lead is deposited on the negative electrode; and this is easily explained; the protoxide of lead not being peroxidized, must be reduced; so that in a few moments after the immersion, we can see whether colouration will take place or not.

* This caution is evidently in reference to directions previously given (Vide Elec. Mag. p. 96.)—Ed.

Digitized by Google

With regard to the preparation of iron and steel, when the plate has been polished, the surface is to be rubbed with alkaline water, and then washed in abundance of water.

On the Process of Colouration.

When a saturated solution of protoxide of lead in potash of the given degree of density, is subjected to the action of an apparatus composed of several pairs, using for the negative electrode a platinum wire or plate, and for the positive a gold or a platinum plate, there is immediately deposited on the latter a film of anhydrous peroxide of lead, which gradually increases in thickness, producing in succession the effects of colour, which coloured rings or thin films present. As soon as the colouration is completed, the plate, that has been coloured, must be removed from the solution of lead, and washed in abundance of water, in order to remove all the potash; as it would immediately react on the peroxide to change it into the protoxide, which it would dissolve. The colouration commonly commences at the edges of the plates, at the parts most distant from the points of connection,—at the parts, consequently, where the chemical action of the current is strongest. On this account it is that, unless previous precautions are taken, it is impossible to obtain uniform colours. The layers of peroxide of lead adhere so strongly, that they support the leather rubber and English rouge, but not the blood-stone or the steel or horn burnisher, because this operation can only be applied to malleable substances, the particles of which extend beneath the burnisher,—a property not possessed by peroxide of lead, and which, therefore, must be detached from the surface on which it is deposited, when the action of the burnisher is sufficiently powerful. Moreover, the adhesion of the peroxide is stronger as the metals, at least their oxides, are more apt to form combinations with this compound; this adhesion is sometimes so strong that the deposit resists for a long time the action of dilute acids.

Peroxide of lead not being a conductor of electricity, it follows that the thickness of the colouring film is very limited.—Before describing the different processes, which we have adopted in order to obtain all the desired effects of colour, I must point out the order which the colouration follows, so that we may be readily able to analyze the effects.

On the Different Orders of Colouration.

The colouration obtained on metallic surfaces by the deposit of successive layers of peroxide of lead is due, as I have said,

Digitized by Google

to the phenomena of thin films, which, on account of their transparency, when there is no oxidation, expose to view the metallic surface on which they are deposited. If this surface is coloured, the colours depend on the thickness of the films united to that which is proper to the body itself; whence result effects which, although they alter the colours of the coloured rings, do not in any degree change the succession of the different orders, which then, however, are not composed of simple colours. With gold, for example, there is no possibility of obtaining blue; because its yellow colour, mingling with the blue, gives a bluish green, very beautiful, it is true, but which is not the blue of the coloured rings. With platinum, we arrive at blue,—at ultra-marine blue,—at the most beautiful blue, which can be obtained. I will now point out how the colours, due to the deposit of successive films of peroxide of lead, succeed each other on a gold plate.

First Order.

First order of the colours of Newton's coloured rings:—Black, very pale blue, vivid white, orange-yellow, red.

First order of the colours of the films of peroxide of lead:—Slight deposit, the colour of which cannot be characterized, so fugitive is it; orange, deep-orange, pearl-grey, verging to greenish, gold yellow, faint red, beautiful prismatic red.

Second Order.

Second order of the colours of Newton's coloured rings:—Pale purple, purple, bright grass green, bright yellow, rose-lake.

Second order of the colours of the films of peroxide of lead:—Red verging to violet, bluish green, beautiful green, yellow, red.

Third Order.

Newton's third order:—Bluish purple, bright grass green, brilliant yellow, rose-lake.

Third order of films of peroxide of lead:—Wine-colour violet, deep green, green verging to red. The colours beyond possess more or less a deep aspect, and finally arrive at jet-black.

In comparing the colours of Newton's coloured rings with those of the films of peroxide of lead, belonging to the same order, very manifest relations are seen; since, with a few exceptions, the only difference is in the tints; in fact, the order of colours follows very well.

On copper, the same orders of colours are observed, except

Digitized by Google

that they are not mixed with yellow, but have rather a reddish tint, which gives them intensity.

On perfectly polished silver, we begin by perceiving a greenish yellow colour, partly due to the oxidation of the silver, then yellow, red, blue and green; afterwards the other colours, which become deeper and deeper.

On platinum, all the preceding colours obtain, in a greater or less degree, a bluish tint; also those which are blue or bluish green, present the most beautiful blue,—a blue exceeding the ultra-marine.

On iron, and especially on steel, the different orders of colours are shown with very great intensity, but in general they are dulled by the gray colour of the metal; I have experimented upon metals void of colour, and those offering the deepest colours. In another memoir I shall examine the effects obtained on nickel, cobalt, &c.

On the different Arrangements to be adopted in order to obtain Uniform or Varied Tints on the Surfaces.

In order to obtain uniform tints, the object must be arranged so that the action of the current shall be the same, on all points of the surface, without which there will be portions more covered with films of peroxide than others; hence arise prismatic colours or tints more or less varied on the same surface, producing an irisation, which would often spoil the picturesque effect. In order to have a single colour, several conditions must be fulfilled, which depend on the chemical properties of currents, and on the skill of the operator.

1st.—The deposits of peroxide must be successive and extremely thin, so as not to pass hurriedly from one colour to another; that is, they must be arranged so as to have successively all the tints of each colour; in this case, the only risk is that of having, on the same surface, tints closely approaching the same colour. This is accomplished by taking, as negative electrodes, platinum wires of from 1 to $\frac{1}{10}$ millimètre in diameter. Each wire is introduced into the interior of a glass tube, one extremity of which is melted at the lamp, and the wire cut close to this extremity, so as to have beyond the tube a metal point, in a measure fixed, by which the current may pass out; in this way a current, produced by a very small quantity of electricity, may be made to circulate in the liquid. At the other extremity, the wire is fixed with mastic, and a certain length is given to it so that it may be connected with the negative pole of the decomposing apparatus. A certain number of tubes, all connected with the

Digitized by Google

pole, are thus prepared, so that the one, suited to the extent of surface experimented on, may be taken. The negative electrode being thus reduced to the smallest possible dimensions,—for it can only present the section of an almost microscopical wire, the deposit of the films is gradual. It must be borne in mind, to remove, from time to time, the deposit of lead; which, however, is not considerable, when the action is slow.

Instead of one tube, which I may call a tube electrode, several are often united together, by cementing one to the other, so that all the points are in the same plain; or else, a certain number of platinum wires are introduced into the same tube, closing with the lamp the extremity by which they are to enter the solution. They are cut off at a certain distance from the tube, and are separated, so as to form an actual pencil.

2nd.—The objects are connected with the positive pole of the apparatus; when they are only two or three centimètres in extent, they are merely attached to an iron or a copper wire, connected with that pole; or else, the object is held with an iron vice, connected with the apparatus, care being taken frequently to file the interior of the branches, in order to remove the peroxide which is deposited, and which, not being a conductor, would prevent the circulation of the current. If the object is of a certain extent, the connecting wire must be multiplied, so that the current may pass by a greater number of points. The object may also be seized with metal pincers, for changing its position, without which the connecting points could not acquire colour. Finally, the more the number of points of contact is multiplied, the more does the deposit approach uniformity. If a square surface of small extent is operated on, a wire is attached to each angle. If the extent is considerable, the plate may be placed on two wires crossed at right angles, and passing by the middle of the sides. With a triangle, the three angles are placed in connection with the positive pole; with a circle, the connecting point must be at the centre. In fact, the law of symmetry, relative to the position of the connecting points, must be complied with; for this is the only means of rendering the decomposing action of the current uniform.

3rd.—If a cylindrical ring is being operated on, the pincers are placed within it, and their branches are opened and kept apart by a wooden wedge; or else a conical mandril is introduced into the interior, which, by being more or less thrust in, allows the article to be fixed on the mandril, which is connected with the positive pole. If the cylinder is short, it is

Digitized by Google

placed on a copper base or trellis, which is in constant connection with the positive pole, care being taken to wash away the deposited peroxide, by a means that we will presently point out. Thus far concerning the mode of connecting objects with the positive pole. I will now point out the mode of operating with the tube-electrode, in order to obtain uniformity or variety of tints.

This electrode must never be at rest; for the deposit would be always more abundant in the nearer points of the object. It is, then, indispensable to move it continually above the surface to be covered, keeping it always sensibly at the same distance, which must be greater as the surface of the objects is less. This is the only means of obtaining equality of distance between the metal point and all the points of the surface, since the oblique lines differ less and less from the perpendicular. This difference, however, is not so great in respect to intaglio and relief, which, without this precaution, would present differences in their colouration. When the bodies are of large dimensions, the point must be still further removed from the surface, and the movement of the tube electrode must be accelerated, so as to pass the point incessantly from the centre to the circumference, if a plain object is being operated on. There are cases in which the point must be removed 1 or 2 decimètres (4 to 8 in.) from the surface. One might think that, by employing solutions of plumbate of potash, more or less diluted, we might more surely attain the object in view, namely, a slow and successive colouration. Theory assuredly indicates this, but experiment proves the contrary; the best results are certainly those obtained with the saturated solution of plombate of potash, giving 24 or 25 degrees of Baume's areometer, at common temperatures. With less saturated solutions, the colours have no brilliancy, and are so slow in forming, that a considerable time is required in order to arrive at all the successions of tint that are sought after. The vessel, in which the operations are carried on, must be of good dimensions in all directions, so as to give freedom for manipulation, and the power of removing the tube electrodes as far from the surface of the objects as may be deemed expedient, while the objects to be produced are themselves in sight. The cylindrical form is the most suitable, because it permits of obtaining a regular action, by moving the tube electrode along its inner surface;—when the objects are of large dimensions, the diameter of the vessel ought to be two or three times that of the objects themselves.

To fix the ideas as to the manner of manipulating with

Digitized by Google

the tube electrode, I will quote some examples. Suppose we wish to cover uniformly, not only the upper surface of a square plate, but both surfaces;—after having arranged a conductor at each of the four corners, the plate is placed horizontally in the solution, and the tube electrode is moved at a suitable distance from its edges, the point being constantly maintained at a level with the plate and on the same plain, so that the action of the current may be the same above and below. If the article has larger dimensions, after having attached to it the requisite number of conductors, the simple tube electrode is not sufficient; there must be a tube electrode with two or with several branches, the wire of each of which leads to another in connection with the positive pole of the decomposing apparatus. I will first consider the tube with two branches, consisting of two tube electrodes cemented to each other, and passed into a cork so short that they may slide one over the other, in the direction of their length. The two closed ends are bent at a right angle, first to a distance, which must, at least, be equal to half the width of the object, and then at a little distance from the extremity, so that the two points may be placed relatively in the same line. The terminal branch needs not be more than half a centimètre long; the plate is placed between the two points, each surface being at the same distance from the point that faces it. This apparatus may be manipulated so as to present in succession each point equally opposite to all the corresponding points of each of the two surfaces. As the length of each fresh bend is equal to something more than half the width of the object, in order to reach all the points nothing more is necessary than to turn the whole system round this object. We repeat, that the double or single electrode must be continually in motion, taking care that each point is always at an equal distance from the surface facing it; otherwise, the electro-chemical action would be stronger on one side than on the other; this condition is fulfilled by means of the following arrangements. On the upper edge of the vessel two small wooden tubes on rods are fixed parallel, and the object, if it is a square plate, is so placed that two of the sides are at an equal distance from its edges. The lower boundary of the great bend of the upper tube is applied to one of these tubes; in this manner the two points are at an equal distance from the two surfaces. If we wish to operate regularly on a circular surface, the tube electrode is slid into the interior of an horizontal copper spiral, the summit of which corresponds with the centre of

Digitized by Google

the circle, and all the points of which are equally distant from the upper surface of the object.*

If we wish to colour the interior of a hemispherical surface, its interior is filled with the solution, and the vessel is connected with the positive pole, by placing it on a copper plate connected with the said pole. The tube electrode is thrust in, so as to place its point in the centre of the section, and it is then left in a fixed position. In this case, the decomposing action of the current is the same on all points of the surface. With a cylindrical vessel, the tube electrode must be placed along the axis, and the point must be constantly carried up and down; if a sphere is the subject, the point must be placed in the centre, and fixed. The law of symmetry is seen to be regarded in all these arrangements.

In order to be sure of passing through all the intermediate tints, with the power of stopping, not only at the colour, but even at the tint desired, the immersion of the tube electrode must not last beyond a few seconds, especially at the approach of that colour or tint. The article is then removed from the bath; the state of colouration is examined; but, when the operation is over, it must immediately be washed in abundance of water; and a current of cold water must be allowed to fall on the article so as to remove the smallest particles of potash, which might very quickly alter the colours.

I have now to make known the method of operation in order to give a surface or a portion of a surface different colours, or tints of unequal intensity, as must be the case in colouring the leaves or other parts of a flower. For this purpose, these two principles must be fundamental;—that the deposits formed on the boundary lines are the strongest, as are also the parts which are nearest to the point of the tube electrode. Nothing is more simple than, by the aid of these two principles, and by taking a certain number of connecting wires, to arrive at the end proposed.

Let us suppose a circle representing the horizontal projection of a rose, and that we wish to colour the central part green; we begin by putting the tube electrode for some seconds above this part; the surface will be covered with a deposit, that will be stronger there than elsewhere. That being done, the tube is carried well away from its first position, that the action may be uniform throughout; green will be produced in the central part, while the lateral red portions will have a tint more uniform, as they are more dis-

* Here, and elsewhere, the original is so obscure that we fear our readers will, with ourselves, find a difficulty in understanding the arrangements.—*Ed. Elec. Mag.*

Digitized by Google

tant from the centre. If shading is desired, the tube electrode is moved on, describing sensibly a spiral, which shall terminate in the centre. Having a certain degree of skill we may succeed, by means of the tube electrodes, in *painting* a simple or a compound flower, with all its shades; so that these tubes may, to a certain extent, be compared with pencils. The perfection of the effects produced depends 1st,—on the electro-chemical knowledge of the operator; 2nd,—on his skill; 3rd,—on his artistic talents.

The coloured objects, that I have the honour of submitting to the Academy, although not uniting all the qualities which electro-chemical colouring may one day present, will, however, give an idea of the advantage, which the artisan may derive from an art, the general principles of which I have here explained.

I omit a host of details, which the operator will easily discover, when he has acquired a certain degree of skill in the manipulations.

When an article fails, nothing is more simple than to remove the films of peroxide;—it must be plunged, for a few moments, in dilute acetic acid, in order to decompose the peroxide and dissolve the protoxide; the surface must then be brushed, and afterwards washed.

Of the Decomposing Apparatus.

In order to obtain all the effects, which have just been described, a decomposing apparatus must be employed, which gives a current sensibly constant during the whole of the operations. It must be easy to manage; and I have found nothing better than pairs, consisting of a copper cylinder 1 decimètre (4 in.) in diameter, and 1½ in height, and a solid zinc cylinder 2 or 3 centimètres in diameter, previously amalgamated and surrounded by the former; each pair is placed in a cylindrical glass jar, and connected with the next in series, by means of the usual arrangements. The battery is charged with water, containing about $\frac{1}{100}$ of sulphuric acid. Six pairs are generally sufficient for all operations. A less number may be employed; but the most satisfactory results have been given me with this number.

The conducting wire, as well as the different connecting parts, must be very clean, in order to avoid irregularities in the action of the current, which would annoy the operator.

We discover if the current has too high an intensity, when, instead of the anhydrous peroxide, the yellow hydrated peroxide makes its appearance; this must then be remedied, for all colouration ceases.

Digitized by Google

On the alteration of colours, and the means of preventing it.

Do the colours produced by the deposit of thin films of peroxide of lead alter in the air more or less readily, according to the methods by which they are deposited? This is an important point to examine, in connection with the applications to the arts. I will point out the causes, by which this alteration is brought about, as well as those which may prevent it, or at least reduce the effects. The observations, which I am about to present, have reference to colouring on gold; because that is produced by successive coloured films of peroxide of lead only, not mingled or combined with other oxides.

All causes, which decompose peroxide of lead, necessarily alter this substance; thus the acids and the alkalies make the peroxide pass to a lower state of oxidation, in order that they may combine with the protoxide. We must, therefore, avoid leaving the coloured objects exposed to acid or ammoniacal exhalations, which, by decomposing the peroxide of lead, alter the colours. The only means of preventing the contact of acid or ammoniacal exhalations, is to place the objects under glass, or to cover their surface with a transparent, durable varnish, which, while opposing the action of vapours, alters their colour in the least possible degree.

I have made a great many experiments on this subject, which it is needless to relate here, in order to study the qualities of all the varnishes, which were at my disposal. The principal facts that I observed, are these: — The best varnish would undoubtedly be that which, being saturated with oxygen, would not take any from the body that it covers. Now, no varnish possesses this property; we are, therefore, forced to take that which is the least alterable in air.

We may distinguish four kinds of varnish: —1st, Alcohol varnish; —2d, Essence of turpentine varnish; —3d, Linseed oil varnish; and —4th, Essence of turpentine varnish; —the resins, employed to make the first two, being either gum lac or gum copal. The first three varnishes are not suitable; for they it is which alter the colours most. The fourth also alters them, but in a less degree, especially when it is saturated with litharge; because it has then less disposition to react on the peroxide. The composition of this varnish is as follows: —In a varnished pot is placed $\frac{1}{2}$ a litre (30 cub. in.) of linseed oil, from 4 to 8 grammes ($61\frac{3}{4}$ to $123\frac{1}{2}$ grs. troy) of litharge, finely pounded, and 2 grammes of sulphate of zinc; a moderate heat is applied for several hours. When the solution of the oxide of lead is accomplished, it is filtered to separate the excess of litharge. If the oil is too thick, it is dissolved in

Digitized by Google

essence of turpentine, which has been previously boiled in a retort on the litharge, so as to take away the succinic acid, which might be there, and which would alter the colours. The varnish being prepared, it is spread on the article with a pencil, in a very thin layer, and is dried at a low temperature. When the article is very dry, a second layer is placed on, which is dried in a similar manner. On the first application of the varnish, the following effects are observed :—The blue of the second order disappears, so that the bluish green becomes yellowish green ; the yellow and the red undergo very little change. With regard to the colours of the third order, especially the deep green, they remain almost untouched.

So that, by means of the varnish, the articles are entirely preserved. When we desire to obtain and to preserve the colours of the second order, with the exception of bluish green and grass green, the instant that bluish green is passed, and yellowish green begins to appear, we must stop the operation, wash, dry and put on the varnish ; the colour is then preserved. I should mention that, as this varnish does not possess perfect transparency, since it is brownish coloured, the colours lose their brilliancy, but gain in solidity. It may be asked, Why are the colours of the third order more eaily preserved than those of the second, and especially than those of the first? We might imagine that the layers of peroxide, being thicker, are more easily preserved; but then, as the first layer disappears, the preceding layer ought to be seen, which does not appear to be the case. Moreover, the disappearance of the blue of the second order, points out a peculiar action of the varnish, of which it is difficult to give an *à priori* explanation. I say an *à priori ;* because the films of oxide of lead are so fine, that the effects which are produced cannot be analyzed. We can only observe these effects, and describe them by resting on the data with which physics and chemistry furnish us. MM. Lefranc, (clever varnish makers), have been kind enough to prepare for me a thick varnish of gum copal, which, in place of altering the blue produced on platinized copper, gives it, on the contrary, greater brilliancy, at least, in certain tints. This varnish is the most durable known.

On the colouring of articles of copper, platinum, silver, German-silver, brass, iron or steel.

All the effects of colouring, which I have just described, have been produced on gold or on gilded copper; these effects take place, whatever be the extent of the surfaces, but

Digitized by Google

it is not the same with brass, and sometimes with copper, there occurs, at the commencement, a phenomenon, with the cause of which I am not acquainted, although I have devised a means of guarding against it.

Brass.—When the article is small, (having 1 or 2 centimètres of surface,) the colouring occurs as soon as the circuit is closed, and the more rapidly as the surface is smaller; but, when it is larger, the article remains brilliant for a long time, and even preserves its brilliancy. The surface is then found in a passive state, analogous to that which iron is made to acquire by various means; for no colouring effect takes place. Is this apparent state of passivity, which is, in a similar manner, possessed by other metals, due to a simple deposit of oxygen on the surface, or to a film of oxide of copper, which is formed before the formation of the peroxide of lead? The facts, which follow, furnish a glimpse at the phenomenon. The apparent state of passivity is indicated by an abundant deposit of lead on the negative electrode, which is easily explained, since there is no peroxide formed.

Experiment having taught that a very small surface is coloured immediately, it follows that it acquires the necessary modification for that phenomenon to take place. That being established, large surfaces of brass may be made to acquire this modification, so that colouring may take place as upon smaller surfaces. For this purpose, a small portion of the surface must be first plunged into the alkaline solution, which becomes coloured immediately; and the neighbouring parts must continue to be immersed, until the whole article is in contact with the liquid.

The modification, which the article then acquires, is indicated by a fugitive cloud, that covers the entire surface, and the colour of which cannot be defined, so fugitive is it; but what there is peculiar and no less astonishing is, that the part first plunged in, which is almost entirely coloured, loses its colour and apparently regains that of the metal, without there being a possibility of recolouring it again; when once the cloud has spread like a shade over the whole surface, in a few moments all the phases of colouring are produced, such as they have been previously described, and the colours of which rival in brilliancy the best of those afforded us by the most polished gold. The enquiry, as we well know here, bears only on the colouring analogous to that obtained on gold and on gilt copper, and not on colouring, the tints of which present a vinous aspect, which is obtained on large articles that have remained a long time under experiment.

When we wish to colour an article having certain dimen-

Digitized by Google

sions, by following the directions that I have now laid down, it is placed on an inclined plane, which is plunged into the solution, and down the length of which it is made slowly to descend. By means of this arrangement, only a small portion of the surface, that has not yet been subjected to voltaic action, is in contact with the liquid at each moment. We might be induced to think, in consequence of the effects which are produced, that, if the dimensions of the negative electrode were increased, a great surface might speedily be rendered active; but such is not the case; for, whether this electrode be great or small, the positive surface, when it has a certain extent, always remains passive; so that, to render it active, the means I have just pointed out must be pursued. With regard to the true cause of the phenomenon, I have not yet perceived it; simply, as the colours are more stable on brass than on gold, it is probable that a combination, or perhaps a mixture, is formed of oxide of copper and peroxide of lead, which further researches may discover. Meanwhile, I must mention that, among the colours obtained, there is, in the second order, a gold yellow, comparable to that of gold; and which even, in some cases, appears identical.

Copper also sometimes acquires the passive state; but less frequently so than brass.

Silver is never passive, when its surface is prepared, by following all the indications that I have given; but its colouring does not in any way resemble that of the other metals, although the different orders of rings may be followed; seeing that this metal speedily undergoes an oxidation, which gives a vinous yellowish tinge to all the colours; when the surface is perfectly polished, and the current is not intense enough to produce any sensible alteration in the silver, very vivid colours may be obtained.

Platinum, and especially platinated * copper, become coloured with the richest blues, that, I think, art can produce. Everything induces a belief that the oxidation of the platinum is concerned in producing these colours, which would be the result of the combination or mixture of oxide of platinum, and peroxide of lead; this point must be treated on hereafter; although blue is the leading colour, nevertheless several colours of the different series of coloured rings are obtained. The violets and the blues that are found among the objects, which I have the honour of presenting to the Academy, will, I think, shew how greatly the blue in question approaches that of natural flowers.

* We follow Mr. Smee's nomenclature of *platinated*, in contradistinction to *platinized*.—*Ed. Elec. Mag.*

Digitized by Google

German silver, dry-rubbed with very fine pounce and a brush, colours very well, without its surface becoming passive, at least in the great majority of cases. When its surface is polished, very beautiful colours may be developed.

Polished steel is easily coloured, when its surface has been properly prepared. We obtain the different tints, which it acquires when heated, over and above the tones, which depend on the successive deposits of films of peroxide.

Conclusion.

The details into which I have entered, both on the analysis of the effects of colouring, as well as on the practical means, by aid of which it may be applied in the arts, are sufficient, I hope, to enable those who wish to undertake it, to do so without experiencing any very great difficultics. In concluding, I may compare the effects that I have observed, with Nobili's electro-chemical rings, which I mentioned at the commencement of this memoir, confining myself especially to those which he obtained with acetate of lead, purposing to examine, in another memoir, the effects which result from the action of other solutions. To obtain the concentric coloured rings, more or less compacted, on a plate of gold rendered positive, Nobili employed a neutral or almost neutral solution of acetate of lead. He has faithfully reported this fact, without seeking to explain it. These rings must have speedily disappeared, as soon as the acetic acid became free,* on account of the reaction, which this acid exercises on the acetate of lead. My mode of experimenting, and the effects which are obtained, are different. The solution which I employ is alkaline, and can be no other, because it is necessary that the oxide of lead, carried to the positive pole and peroxidizing, should play the part of an acid, in respect to the potash; in order that the adhesion may be as strong as possible, which could not be the case if we operated with acetate of lead, or with any other salt of lead, because the oxide acts the part of a base. On the other hand, there are always coloured rings in Nobili's experiments, whilst, in my mode of experiment, uniform tints may be obtained on surfaces of a certain extent,† which are durable and very adhesive. Nobili sought after coloured rings; I have avoided them. There is really nothing in common between Nobili's electro-chemical

* We have not found this in any way the case, in our own experiments.—*Ed. Elec. Mag.*

† Mr. Gassiot and ourself coloured, long since, by Nobili's mode, a series of 2-inch steel plates, each with a several tint.—*Ed. Elec. Mag.*

Digitized by Google

coloured rings, and the phenomena of colouring here in question, except in that both are produced by thin films.

In a third memoir, I shall explain the effects obtained by operating on plates of copper or other metal, covered with a metallic film or oxide, so as to shew the extent to which the effects, which have been described, may be varied; in fact, I will omit nothing which may throw light on the new art, the foundation of which I desire to lay. [A.]

XXXVI. *Studies of Electrical Photometry.* By M.A. Masson. First Memoir. (Extract by the Author.) From "Les Comptes Rendus." 19th February, 1844. No. 8, p. 289. Vol. xviii.

(TRANSLATION.)

The electrical light experiences variations in its intensity, which are so connected with the other effects produced by electricity, that the study of these variations and their measure must lead to a more intimate knowledge of an agent, which, by metamorphoses, not as yet understood, gives rise to all the phenomena attributed to several causes.

In order to obtain the relations, which exist between the electric fluid and its luminous effects, I have sought to measure the intensity of electrical sparks. In the impossibility of employing, in my researches, the known photometers, all of which are only applicable to fixed lights, to estimate the relations of the intensities of lights, whose mean duration may be estimated at a millionth of a second, I have employed a process, which depends on the following principles.

If a disc, covered with black and white sectors, is made to rotate rapidly in presence of a fixed light, a white disc will be seen, the cause of which is well known. If the illumination is produced by an instantaneous light, the circle will appear fixed, and the sectors will be plainly distinguishable.

If the disc is simultaneously illuminated by a permanent light and an instantaneous light,—an electric spark, for instance,—the sectors will be seen, provided that the instantaneous light exercises sufficient illuminating power upon the disc. The necessary illumination will depend on the sensibility of the organ, and on the intensity of the fixed light. But, in all cases, the relation which ought to exist between the intensities of the two lights, in order that the sectors may be effaced, will be constant for the same individual, and the same condition of the organ. It is generally admitted that, if a very

Digitized by Google

slight shadow is projected on a piece of white paper, it will be seen distinctively, especially when moved, if it produces about $\frac{1}{60}$th difference of illumination. In our experiments, we may take about this limit for the relation of the intensities of the fixed light and the instantaneous light, at the moment when the sectors cease to be visible: this limit we well know will vary with the sensibility of the organ. In order to explain the analogy between the effects produced on our apparatus by the instantaneous light, and those which are obtained by projecting a slight shade upon a white field, we must here enter into a few details. When the disc moves rapidly, and is illuminated by a fixed light, it appears white, and the sensation produced is permanent. At the moment, when the instantaneous light illuminates the sectors, the parts of the visible circle, corresponding to the black sectors, act on the organ as if the instantaneous light did not exist; and the others, on the contrary, receive an increase of illumination. Under these circumstances, the following conditions maintain:—the eye perceives sectors, having the same degree of illumination as the disc has, when the instantaneous light is not in existence; and other sectors a little more illuminated. This difference, which is simply due to the instantaneous light, renders evident the division of the disc into sectors; and, from what we have said above, this difference is a fraction of the fixed light; the relation between the two illuminations, depends on the organ of the observer. It is useful to remark here that, if the white and black sectors present equal surfaces, the illumination of the disc is one-half of the illumination, which the fixed light would produce on a disc entirely white; it would be only the tenth, if the black sectors occupied a surface ten times greater than that of the white sectors. Consequently if, when comparing fixed lights with an instantaneous light, an error is committed in the measure of the illuminations produced by the former, this error must be divided by the relation of the surfaces of the black and white sectors, in order to obtain the error committed on the total measure of the fixed light.

The apparatus, that I have employed, and which I designate by the name of *Electrical Photometer*, is composed merely of a disc of 8 centimètres (3 in.) in diameter, having 60 equal sectors. It is moved by a clock-movement, and makes two or three hundred rotations per second.

The elements, whose influence I have studied in relation to the intensity of electric light are the following:—

1st.—The striking distance which I shall designate x;

2nd.—The distance, y, of the spark from the disc;

Digitized by Google

3rd.—The distance, z, of the fixed light from the photometer;

4th.—The surface, s, of the condensers, which were formed of plates of glass, covered with tin-foil;

5th.—The thickness, E, of these condensers;

6th.—The nature of the poles of the spark.

In a future memoir, I will give the influence of the conductibility of the circuit, along which the spark traverses, and the action exercised by the variations in the condensing power of the condensers.

Numerous experiments have conducted me to laws, all of which are comprised in the following formula.

$$I = \frac{K\,[I + m(x - I)^2 s]}{y^2 E}$$

K and m are constant, being functions of the conductibility of the circuit, and the condensing power of the condensers;

I is the intensity of the illumination produced by the spark, at the unity of distance;

The intensity of the electric light is not in the least degree modified by the form of the surfaces.

The nature of the balls, between which the spark is produced, changes the absolute value of the intensity, without altering the laws contained in the preceding formula.

Our experiments have led us to admit that the electric light is a simple explosion in the etherial fluid, which it puts in motion; and to believe that the metal, transported by the sparks, is not the cause of the light;*—it augments it, by producing an increase in the conductibility of the circuit. We think, moreover, that the electric spark acts in chemical combinations and decompositions in two ways; first, as an electric current, and, in this case, it decomposes; secondly, as a body in a state of ignition, on account of the ponderable substances which it transports, and then it produces combinations.

When the conditions of the production of the electric spark remain invariable, the intensity of its light is fixed; which induces us to believe that we have at last found a constant photometric unity. It is needless to add that the Electrical Photometer may serve not only to measure instantaneous lights, but also to measure fixed lights; and that, by giving it different forms, it may be employed in the study of the intensities of the different parts of the luminous spectrum. [A.]

* Vide Fusinieri's paper; supra, p. 235.

Digitized by Google

XXXVII.—*Majocchi's Universal Galvanometer.* From a Treatise on Electricity, by Prof. Majocchi, p. 409. Communicated by the Author.

(ABSTRACT.)

THE object of this instrument is to do away with the inconvenience, which the ordinary multiplier presents, of being too delicate for measuring powerful forces, when constructed for small forces; or of being inefficient to detect small forces, when constructed for the more powerful. So that to answer the several demands, "it is requisite," as the author says, "that several others of different sensibility should be prepared, in order to obtain the measure of currents in all cases."

The universal galvanometer is described as being applicable to all purposes of current-measuring;—"it serves equally well to measure weak currents of electricity as those of moderate, and those of very great intensity. This instrument is sufficiently sensible for the thermo-electric current; in short, its galvanometric circle, besides measuring the *hydro-electric* or *voltaic* current, and the so-called *chemico-electric* current, serves also for estimating the force of *induced currents* of every kind, that is, both those of *common* and those of *magneto-electricity*. For comparatively weak currents, the instrument can be arranged in such a manner that the resultant of the action is doubled by causing the electric fluid to circulate around the magnetic needle, at the smallest possible distance; while the action is single for currents of greater or less energy, and is made to act at a greater or less distance, according to their degree of force,—and in such a manner that the electro-dynamic impulse does not make the needle go over the entire quadrant."

A tripod-stand, with adjusting screws for obtaining a horizontal level, supports a hollowed pillar, on which is placed the graduated circle and other essentials of the galvanometer. The conducting wire passes but once round the needle; the length below the needle is a fixture, being secured in the base of the graduated circle; the portion to pass above the needle, and also perpendicularly to complete the parallelogram, is contained in a glass tube, bent twice at right angles: as thus, the ends hang loosely out of this tube, and can be either connected respectively with the battery terminals direct, or by the intervention of the other fixed portion of the galvanometer-wire just described: in the one case the current will pass only above the needle; in the

Digitized by Google

other it will pass both above and below, or it may be made to pass below the needle only along the fixed wire. Proper adjustments, and connecting pieces are arranged in the margin of the circle, for effecting these several variations.

The other feature, conspiring to the general use of this instrument, is the varying distances, which the two parallel wires above described may be made to assume. The glass tube, above mentioned, fits tightly into two holes in the base of the circle, in such a manner that, by being drawn up, or pressed down, the horizontal part of the wire may be brought nearer to, or removed further from the needle.—In order to increase or diminish the distance between the fixed wire and the needle, the needle itself is movable. The pivot, on which it turns, is fixed in a stem, that passes into the hollowed part of the pedestal column. The stem is furnished with rack-work, and a pinion, by means of which it is raised or lowered; and with it, of course, the distance of the needle from the lower wire is varied. A glass shade covers the whole. The instrument is furnished with one other rack and pinion, in order to complete its adjustment into the magnetic meridian.

The author's account of his mode of using the instrument, which we give almost verbally, will serve as an illustration of this description:—

When wishing to use the instrument, I commence by arranging it on a table near me, or on the experimental table, by adjusting the several screws, so that the graduated circle shall be arranged horizontally; which is easily discovered from the position of the magnetic needle becoming parallel to the plane of the graduated circle. In this first arrangement of the galvanometer, care must be taken to place it, so that the plane, formed by the two wires, shall closely coincide with the magnetic meridian, indicated by the static condition in which the needle places itself. If this coincidence does not entirely occur, the needle is adjusted to a due position, on turning by its handle the ratchet and pinion, above mentioned, which gives a rotatory movement to a toothed-wheel, connected with the lower part of the graduated circle. All the objects fixed upon this circle turn with it; and, consequently, the plane that passes through the wires acquires also a rotatory motion, by which they may easily be brought into the direction of the magnetic needle. When estimating the strength of very weak currents, the needle is lowered, until almost to touch the lower wire, by means of the screw: the other wire is, in like manner, lowered until almost to touch the upper side of the galvanometric needle, by drawing

Digitized by Google

down the glass rod as far as needful. The proper connecting pieces are then placed in. The connecting wires of the current, the measure of whose force is to be examined, are then attached, so that the current shall pass in one direction above, and in the other below the needle. The electric current will excite, therefore, a double action upon the needle, and will be at a distance much less than that which occurs in the multiplying galvanometer. Notwithstanding the weakness of the current, a deviation in the needle will occur, and which will be indicated in degrees on the circle placed beneath it. When the currents are stronger,—such as are capable with this arrangement of communicating impulses to the needle, so as to make it describe an entire quadrant, then the upper wire must be elevated by pushing upward the glass rod; and the needle may easily be removed far from the other wire, by turning the pinion. If the electric current is so energetic that its double action along the two wires is too sensitive to the needle, it may be made to pass by one only of these wires; for example, by the lower alone, in the manner described above.

The rod, on which the needle is poised, is divided into millimètres, by which means the distance of the needle from the wire may be measured:—so that, according to the fundamental law, that *the force of an indefinite rectilinear current is in inverse ratio to the distance*, the measures may be compared, when the needle is placed at different distances.

This galvanometer, moreover, serves for the electro-dynamic measurements, of every current, weak or strong; it also serves as a differential instrument to discover, that is, the difference between two currents, one of which passes along the lower, the other along the upper wire,—the wires being arranged at equal distances from the needle. Majocchi's instrument greatly facilitates this mode of experiment; by its means, some useful researches may be successfully conducted; he has applied it to establish the relative conductibility of liquids. It may also be used in class-illustrations of Œrsted's experiments, on the mutual action of magnets and currents. [B.]

XXXVIII.—*On the Ignition of Metals in Acid Solutions.*

By Mr. Mackrell.

(*To the Editor of the Electrical Magazine.*)

Cloudesley Square, 11th Dec. 1843.

My dear Sir,—In the second number of the Elec. Mag.,*

* Page 121.

Digitized by Google

are some remarks by Professor Grove, on various voltaic phenomena,—the last of which relate to the peculiar action occurring when, with a very powerful voltaic battery, "small wire electrodes of platinum are dipped into water acidulated with sulphuric acid,—a brilliant combustion, attended with a decrepitating noise, is observed at the cathode, provided the anode is previously immersed in the liquid; on reversing the experiment, a slight spark only is observed at the anode."

The brilliancy of the phenomenon is there described, as being due to the strong affinity between the platinum cathode and the sulphur of the sulphuric acid. Having, in the early part of 1840, made several experiments on this particular phenomenon, (a notice of some of which was published in the Proceedings of the Electrical Society,*) I cannot help thinking, that this combination of the sulphur of the acid with the metal of the cathode, is rather the effect than the cause of the phenomenon,—the latter of which still seems to require elucidation.

I have carefully repeated my former experiments, with the assistance of my friend Mr. Pollock, and made others—some of which were performed in muriatic acid, and others in nitric acid; and the results were precisely similar to those made in diluted sulphuric acid;—that is, the combustion was exceedingly brilliant at the cathode, when last immersed in the electrolyte; but at the anode, when the experiment was reversed, the combustion was comparatively feeble.—Wires of iron and copper, and plates of platinum a quarter of an inch in width, were also used, instead of platinum wire, with analogous effects.

In the case of the cathode, when introduced last into the solution; if, instead of diluted sulphuric acid, muriatic acid is employed as the electrolyte, hydrogen is of course evolved; but the affinity between hydrogen and platinum we know to be very weak; yet the phenomena are as brilliant as when sulphur in the former instance is concerned;—and perhaps more so.

Then again, if nitric acid be substituted, from which hydrogen, azote, or ammonia are disengaged, the affinities of these bodies for platinum are weak, yet the phenomena are most brilliant. In the case of the anode, the phenomena are less brilliant than those at the cathode, although the existing affinities of the platinum for the oxygen, and more particularly for chlorine, are stronger than those of the cathode platinum for the hydrogen, the azote, or the ammonia. These results appear to indicate that the strong affinity of the

* Page 6.

Digitized by Google

cathode platinum for the sulphur is not the cause of the brilliancy of the phenomena.

I think it proper, however, to state, in conclusion, that these experiments were made in the acids of commerce, which are not entirely pure; my occupations not having yet allowed me time to repeat them in pure acids, which it is my intention to do as I have more leisure, when I shall feel much pleasure in forwarding you the results.

I remain, my dear Sir, Yours very truly,

G. MACKRELL.

C. V. WALKER, ESQ.

XXXIX.—*On the Action of Buried Plates.* By the REV. F. LOCKEY, A.M.

(*To the Editor of the Electrical Magazine.*)

Bath, March 8th, 1844.

DEAR SIR,—I should have had much more pleasure in complying with your request to hear the results effected by the action of copper and zinc plates, deposited beneath the surface of moist ground, had those results been of a more successful character. They are not indeed without some interest; and if the action, feeble as it is, continue with tolerable constancy for some months, such a battery may, for certain classes of experiment (e. g. in mineral crystallization, electro-metallurgy, &c.), form a useful source of electrical power; if otherwise, I fear that the expression of Horace, *parturiunt montes*, &c., will but too justly apply to such an arrangement, as I have now to describe.

The buried plates, which I have used, are sixteen in number, deposited horizontally with a layer of garden mould, two inches in thickness, between each. Of these, eight are copper plates, *each* containing nine square feet of single surface: the remaining eight are zinc plates, *each* containing more than ten square feet of single surface. The plates are so connected as to avoid cross action, and to bring both surfaces of the metals into use (except the outer surface of each terminal plate). The total surfaces of *both* metals may therefore be reckoned not less than two hundred and ninety square feet.

Local circumstances unfortunately render it necessary that the wires conducting the current to the place of experiment should be seventy-five feet in length, forming a circuit of 150 feet. They are, however, well insulated in every part.

Arranged *in a series* of four double pairs, iodide of potassium was readily decomposed, but acidulated water yielded

Digitized by Google

only one-thirtieth of a cubic inch of the mixed gases in an hour, the electrodes being of platinum wire about one-eightieth of an inch in diameter. The decomposition of metallic solutions was readily effected. The needle of a common galvanoscope (Schweiger's) indicated a permanent deflection of 42°. A gold-leaf electroscope is not affected.

Arranged *as a single plate,* the following effects have been observed:—

1. A minute spark on breaking contact,—its size being greatly increased by the interposition of a copper-ribbon-coil, and more so still by an electro-magnetic coil.

2. Scintillations of fine steel wire drawn along a file or over lacquered iron, brass, &c.,—the scintillations being sometimes three-quarters of an inch diameter.

3. No success attended the attempt to ignite a small portion of very fine platinum wire.

4. Marsh's vibrating wire, between the poles of a permanent magnet, oscillated freely, but feebly.

5. The galvanoscope gave permanent deflection of 60°—momentary contact causing it to whirl round with impetuosity.

6. With half the number of plates in action, a pair of electrotype medals (containing about three square inches) were formed from a solution of sulphate of copper. They became unnecessarily thick in four days, the deposit being remarkably fine, firm, and tough.

7. The rotating electro-magnet of Ritchie revolved with a rapidity amounting to about 400 revolutions in a minute.

8. A heavy, rotating Ritchie (in length five inches and a-half, in diameter six inches) made thirty-eight revolutions in a minute, shewing, with my mercurial contact breaker, a circle of minute sparks.

9. An electro U magnet, each limb three inches and a-half long, and ·6 diameter, sustained rather more than 16 lbs. In order to sustain this weight, the battery needs a *rest* of twenty or thirty minutes. If contact is once broken, when the above weight is suspended, it will not sustain more than 4 or 5 lbs. on a fresh contact, until a period of rest has restored its power.

10. A constant bee-like hum was kept up by the rapidity with which contact was made and broken in that coil apparatus (I forget its author's name)* in which contact is broken by the attraction of a disc of iron towards a bundle of iron wire (an apparatus which, by the way, might not be unsuitably called the galvanic wasp, from its seemingly angry hum and the sharpness of its shock).

* Originating, we believe, with Dr. Golding Bird.—*Ed. Elec. Mag.*

Digitized by Google

11. The shocks obtained from the secondary wire of a coil apparatus were sufficiently severe to be unpleasant to some persons; and, in a few minutes, contracting the muscles of the hands and wrists,—not however with sufficient power to prevent relinquishing of the handles. The hands were not wetted.

I am, my dear Sir,
Very faithfully yours,
F. Lockey.

C. V. Walker, Esq.

XL.—*On the Fracture of Leyden Jars.* By Geo. H. Bachhoffner, Ph.D., M.A., Giessen; Prof. of Exp. Philosophy, Queen's College, Guernsey, &c.

The experience, that I presume I may have acquired from the daily experiments, which I have made for many months, first with the largest electrical machine in existence, and now with the enormously powerful hydro-electric machine, both in the Lecture Theatre of the Polytechnic Institution, — experiments, in which I charge one large battery of about eighty feet of coated glass, at least 100 times per week,—has led me to draw certain conclusions respecting the causes operating to produce the fractures of Leyden jars, which are to us a source of so much annoyance, and a cause of no inconsiderable expense. The causes may briefly be expressed in the following propositions:—

1. "When a Leyden jar is *charged*, the particles of the glass are forced into a polarized and constrained condition, by the electricity of the charging apparatus. *Discharge* is the return of these particles to their natural state." (Faraday's Exp. Researches, § 1300.)

2. From the known velocity of the electric fluid, its passage through and from any apparatus may be considered as instantaneous; for although every body or agent producing an effect upon another, either by its own motion, or by some force emanating from, or communicated by it, must, in the production of that effect, occupy a determinate portion of time; yet, as in the electric fluid and light, the effect may be exerted with such rapidity, as to preclude the possibility, so far as short distances are concerned, of our estimating it by any sensible portion of time.

3. The polarization of the particles of a mass must be effected by a change of position, at least in reference to each other where the mass is in a neutral state; and, consequently,

Digitized by Google

a definite portion of time is required, depending probably upon the density of the mass, the number of particles, the distance at which the force acts and its intensity, not only to overcome the inertia of the particles, but to allow of their definite arrangement. That is, *time is an essential in the production of the effect.*

4. On the discharge of the jar, the particles return to their original position, demanding a portion of time, in some degree corresponding to that requisite to effect their polarization.

5. When the charge is very high in the jar or battery, and the polarization of the particles has been carried to the maximum, and any attempt is made to increase the effect, a degree of strain or tension upon the particles of the mass may be produced, so as to overcome the attraction of cohesion at some weak points, and thus effect the discharge at the fracture.

6. From the observations which I have made with our battery of 24 jars, exposing between 80 and 90 square feet of coated surface, for nearly two years, during which time the battery must have been charged at least 2000 times, and by which I have had more than 30 fractured jars, I find that it is seldom, if ever, that the discharge occurs as in No. 5, the fracture being accompanied either by a spontaneous discharge over the uncoated portion of the jar, or by the descent of the grain-weight electrometer, and the transmission of the charge through the appropriated circuit, and without any apparent loss of power.*

7. If a battery be highly charged, and the jointed discharging-rod, or any other good conductor be suddenly employed in effecting the discharge, by which I mean the connection of the inner and outer coatings being made at the same instant, one or more of the jars will be fractured nine times out of ten, as positive experiment has abundantly proved to me.

8. It is highly probable that the difference of density, difference of chemical combination, and unequal arrangement of particles in certain parts of the glass, may materially impede the necessary motion of the particles producing the polarized state; so that, at these parts more or less time may be requisite, to effect an equal degree of polarized intensity, corresponding to the other portions of the jar or jars; and, in like manner, during the discharge, more or less time would be necessary to effect their restoration to the natural state.

9. If this view be correct, could we not readily account for the fracture of the jar, by the part fractured being still in a

* This fact is noticed by Dr. Priestley in his history, p. 645.

Digitized by Google

polarized or opposite state, while the other parts of the vessel had been restored.

10. This mode of viewing the question also readily explains the cause of the residual charge, which, agreeably to the above view, results from the time requisite to effect the discharge not being adequate to the time necessary to restore all the particles to their original or depolarized state.

Royal Polytechnic Institution Regent Street,
March 1st, 1844.

A Case of Ball Lightning. Communicated by Captain JOHN STEWART.—From the Journal of the Hon. East India Company's ship, "Lady Melville," under his command at that time.

26th June, 1818.—Lat. 37° 35′ South, Long. 41° 23′ East; a fresh breeze under third reef topsails; rate of going, nine miles per hour.

"At four A.M. a great deal of wind; lightning, and heavy black clouds passing over head;—at half past six, a ball of fire struck the main-mast, passed through the upper deck, making a hole about eighteen inches in diameter, and four feet from the mast, when it exploded on the gun-deck with a tremendous noise, and forcing the deck upwards, abaft the main-mast.—About a quarter before seven, another ball of fire struck the main-mast, or seemed to strike it, as it was entirely enveloped in flame. Ascending upwards, passing through the centre of the mast, about eighteen feet, it exploded with a loud cracking noise like a roll of musketry, with vivid sparks, and breaking several of the large iron hoops, which surround the mast, and scattering the fittings of the mast in all directions."

A thick four-inch nail, which was in one of the hoops, is in my possession, the head of which is fused with a hole longitudinally through the centre, and escaping about half way down the nail, which is melted at this part of it.

Upon this occasion, one seaman hastened upon the first occasion to look at the hole in the deck, when the ascending flame scorched him from the feet upwards; he died twelve days after in extreme agony.

Several seamen appeared sensibly affected by it. Upon examining the mast carefully, there remained no appearance

Digitized by Google

of fire; nor was the mast materially injured beyond five of the iron hoops being broken, and the fittings thrown out, which was of little consequence;—the compass did not appear to be affected by it, nor did there appear any smell.

JOHN STEWART.

XLII.—*Roberts's Voltameter.*

IN the fourth volume of Sturgeon's Annals of Electricity, No. 23, page 401,* Mr. Roberts has described a form of Voltameter, by means of which "the trouble and often difficulty of refilling the tube with the liquid to be decomposed" is entirely obviated. For a description of the original instrument, we refer to the Annals. Our present object is to embrace an opportunity, which has just occurred, and, by describing a form, in which this arrangement of Mr. Roberts's has, within these few days, been presented to us, to remind our readers of the existence of an instrument, which cannot fail in being of essential service to the practical electrician.

Fig. 1.

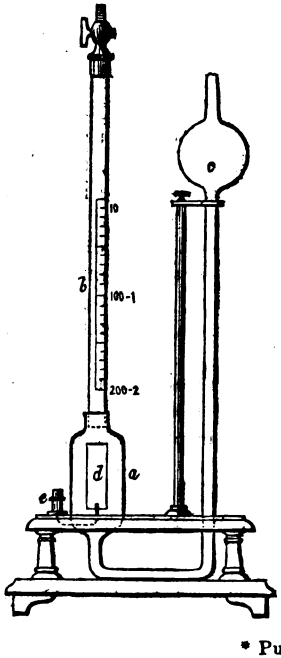
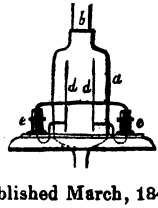


Fig. 2.



The instrument, that is the object of this present notice, was constructed under Mr. Gassiot's direction, and exhibited by him at the Soirée of the London Institution, held on the 20th of March.

Fig. 1 represents a side view of the instrument.—*b c* is a U tube of glass; the part *a* contains the platinum electrodes *d*, of which an end view is given in Fig. 2; the tube *b* is ground so as

* Published March, 1840.

Digitized by Google

to fit tightly in *a*; it is graduated at the lower end, and terminates above by a stop-cock; the other branch terminates above in a globe *e*, from which rises a short tube closed by a screw as occasion requires. A brass rod is added to give firmness to this branch. Battery connection is made by the binding screws *e e*. The instrument is charged for use by pouring the electrolyte into the branch *c* until it rises to the zero of the scale in branch *a;* the stop-cock is then closed. When electrolysis commences, the liberated gases displace the liquid from the tube *b;*—a proportionate rise occurs in the other limb, and the accumulated liquid is retained in the globe *c*. When the experiment is completed, the cock is opened,—the gas escapes,—the liquid regains its level, and is ready for a second experiment. Such an instrument may be kept in the circuit, and thrown into or out of action as occasion demands, by means of a wire, placed in the mercury cups *e e*, in Fig. 2.—C. V. W.

XLIII.—*On the Hydro-Electric Machine.* By the Editor.

In order faithfully to fulfil our engagement to give a description of portable forms of the Hydro-Electric machine, we have let no opportunity pass of collecting information. We gladly avail ourselves, as a preface to this notice, of the reports of two lectures on this subject, recently delivered by Mr. Armstrong, and we give them in the exact words of the reporter of the local journal, because they are so peculiarly characteristic of the great interest which the public generally are taking in these important accessions to science.

"Hydro-Electricity.—On Monday evening last, Wm. G. Armstrong, Esq., solicitor, of this town, delivered a lecture on this new and interesting subject, in the Lecture-room of the Literary and Philosophical Society. On no similar occasion do we remember the public attention to have been so strongly awakened, for not only was the room filled to overflowing, but great numbers were obliged to depart, unable to obtain admittance, whilst a few, more persevering, gained entrance by one of the windows. This intense interest on the part of the public arose from the circumstance of Mr. Armstrong having himself been the chief investigator of this important addition to practical science, and from his having also invented the gigantic machine now in the Polytechnic Institution of London, where it has been visited by Prince Albert, and has attained a European celebrity. A small and extremely elegant

Digitized by Google

hydro-electric machine was exhibited, which (as well as that now at the Polytechnic Institution) was constructed by Messrs. Watson and Lambert, of this town, from the designs and under the immediate superintendence of Mr. Armstrong. The large table also was covered with a variety of electrical apparatus, among which was a powerful glass electrical machine, formerly belonging to the father of the late lamented Mr. Buddle. Mr. Armstrong first noticed the discovery of electricity in steam, by a workman at a fixed engine on the Cramlington railway, in 1840, and detailed the successive steps by which the hydro-electric machine had been brought to its present state. The efficiency of this mainly depends on the peculiar construction of the orifice through which the steam escapes, which was illustrated by large diagrams. Before exhibiting the powers of the new machine, Mr. A. gave a concise outline of prevailing theories of electricity. It was now satisfactorily ascertained that the evolution of electricity which attends the emission of high-pressure steam is occasioned by the friction sustained in the discharging orifice, *not* by the steam itself, but by the small portion of pure water which accompanies it. The lecture was illustrated by many beautiful experiments, the novelty of which rendered them extremely interesting. Among these was the exhibition of brilliant sparks from the hydro-electric machine; and in ten seconds, it produced the same results in charging a small battery that required two and a half minutes by the powerful glass machine already mentioned. A large battery containing fifty-two square feet of coated surface, was repeatedly charged, and gold and silver wires were deflagrated. The opposite electrical conditions of the boiler and steam cloud were displayed by means of an electroscope. The nature of St. Elmo's fire was shown by Mr. Armstrong holding his hand near a jet of steam, when streams of blue electric light seemed to issue from each finger; and an artificial thunder cloud, discharging its electricity through a lightning conductor, set fire to a wood model of a tower. Whether as regards the novelty and importance of the subject, the variety and splendour of the experiments, or the concise and lucid explanations which accompanied them, the lecture was one of the most popular and attractive ever delivered in this town."—*From the Newcastle Courant, Friday, Jan.* 19*th*, 1844.

"HYDRO-ELECTRICITY.—Mr. Armstrong's second and concluding lecture on this subject was delivered on Friday evening last, in the lecture-room of the Literary and Philosophical Society of this town. Mr. A. first called attention to an improvement which he had made a few days previously, in hydro-electric machines, and which, though not matured, he would take that opportunity of explaining. This improvement consists of the introduction of a tin rod, coated with mercury, in each of the condensing pipes, by which the development of electricity is greatly increased; so much so, that the small machine used on this occasion was shown to be nearly equal in power in charging a battery to the colossal glass

Digitized by Google

machine lately used at the Polytechnic Institution in London, and which is the largest of its kind ever made. A number of experiments were performed by the aid of this hydro-electric machine; amongst which were the deflagration of wires of different metals—illuminated chain suspended from the ceiling—electric light in a Torricellian vacuum, and other interesting and brilliant effects. Mr. Armstrong then, by several experiments, clearly demonstrated that the presence of a small portion of distilled water in the issuing steam is essential to the production of electricity, for when the condensing pipes are heated the electricity wholly ceases. That the material of which the orifice is formed is of importance, for by using ivory instead of wood for the mouthpiece, the electricity was rendered exceedingly feeble; and that the excitation of the electricity arises from the friction sustained by the particles of water accompanying the steam in passing through the discharging orifice. He then noticed a curious class of phenomena in which the electricity produced is controlled in quantity, and in some cases changed in nature, by impregnating the ejected water, and by generating the steam in contact with different metals, or varying the material or internal surface of the condensing pipes, showing by experiments that the production of electricity is almost entirely prevented by passing the steam through an iron condensing pipe with a *bright metallic* surface within, while an iron pipe with an *oxydized* interior is highly favourable to the action of the machine. Mr. Armstrong also showed that the electrical states of the boiler and steam cloud might be reversed by using a brass condensing pipe and introducing a small quantity of neutral salt, formed by dissolving brass in nitric acid. Other experiments, illustrating the peculiar properties of the hydro-electric machine, were introduced in explanation of different portions of the lecture, affording a clear insight into its nature, and delighting the audience by their brilliancy. After some appropriate comments on the disposition which too frequently exists to undervalue new discoveries, on the ground of their not being what is termed of a "practical nature," Mr. Armstrong concluded as follows:—"The phenomena of hydro-electricity, when fully investigated, promise to elucidate much that is obscure in electrical science; and whoever reflects on the extensive agency of electricity in chemistry and meteorology, and its probable influence in all the operations of nature, organic and inorganic, cannot fail to appreciate the importance of every new fact that can be rendered available as a stepping-stone to further discovery in this interesting science. The investigation of hydro-electricity has already given rise to a machine which will materially aid future researches in electricity, and which, when its powers become fully developed, may possibly admit of direct application to arts or manufactures. But it is not alone in a utilitarian point of view that philosophical investigations are of value. We have intellectual as well as physical wants to satisfy, and if researches in natural philosophy had no other effects than gratifying a laudable curiosity

Digitized by Google

respecting the mysteries of nature, and contributing to mental cultivation and enjoyment, they would still be of eminent service to mankind." The room, as on the preceding lecture night, was densely crowded, and many persons, on both evenings, having been unable to obtain admission, a general wish has been expressed that these interesting lectures should be repeated in a larger place, which we hope will be realized."—*Ibid.*, *Friday*, *Jan. 26th.*

Our readers will see, in the above report, that a case has occurred, in which the power of one of these machines was very highly exalted by the use of mercury. The precise action had not then, nor has it yet, been discovered.

The following note, respecting *The employment of amalgamated tubes, and the introduction of extraneous matters into the condensing pipe*, has been communicated to us by MR. ARMSTRONG.

"It is only under certain conditions of the apparatus, which at present I am unable to define, that advantage can be derived from the introduction of amalgamated tubes into the condensing pipes. In the course of a considerable number of experiments, made with the hydro-electric machine which I used at my recent lectures, I obtained, on an average, nearly twice as much electricity with the tubes as without them; but the advantage of employing them gradually diminished, as I continued to use the machine; and eventually they became of no service whatever. Conceiving that the newness of the machine might have been concerned in producing the increase of electricity, which I had thus obtained, I repeated my experiments with another machine, which had very recently been completed; but could not in any degree exalt its action by the use of the tubes, so that the cause of this singular effect has for the present escaped my detection, but I trust I shall soon be enabled to discover it.

"I have lately made some experiments, which possess considerable interest, as showing how exceedingly small a quantity of extraneous matter is sufficient to change the electric property of water, and cause it to evolve by friction, *negative* instead of positive electricity. When a brass condensing pipe is used, which has been previously filled with dilute nitric acid, and afterwards washed out with clean water, so as apparantly to remove all remains of the acid, the insulated boiler yields *positive*, instead of *negutive* electricity; and continues to do so for a great length of time. Now there can be little doubt that this effect is owing to the condensed water becoming faintly impregnated with a salt, formed by the union of the nitric acid with the material of the pipe, and not

Digitized by Google

wholly exterminated by the previous washing; because the same effect is produced, without using the acid, by introducing the salt itself into the condensing pipe, though in this case the effect is not so durable as in the other; but the wonder is how the extremely small quantity of this soluble salt, which may be supposed to remain in the pipe after being washed out with water so as to render the metal in appearance perfectly clean, can be sufficient to reverse the electricity, not for a few seconds only, but during repeated trials for several successive days.

"The electricity of the boiler and steam-cloud may be reversed in a still more decided manner by filling the condensing pipe with a solution of acetate of lead and then draining out the liquid; when sufficient of the salt will remain to render the boiler very highly positive for a considerable time. Many other metallic salts produce similar effects, but none that I have tried act so powerfully as acetate of lead. It is also to be observed that whenever the boiler is rendered *positive* by any of the means I have mentioned, its negative state may be immediately restored by filling the condensing pipe with a solution of potass.

"These results harmonize with those which I obtained two or three years ago, by introducing nitric acid and other substances into the gun-metal boiler which I then used. The explanation which Dr. Faraday has suggested for the change of electricity, which is effected by using oil of turpentine, cannot be applied to these cases, in which the extraneous matters employed being *soluble* cannot, like oily substances, form a protecting film over the surface of the ejected globules of water.

"A brass condensing pipe is the most favourable for these experiments, which at all events should never be performed with the ordinary condensing pipes of the machine, for it is often difficult afterwards to restore the apparatus to its full power.

"W. G. Armstrong."

There are several forms which have been given to the portable hydro-electric machines. The first to which we may allude is one constructed by Watson and Lambert, for Mr. Addams, the action of which was exhibited last summer before the members of the United Service Institution; and the power of which we have ourselves had the opportunity of testing with Mr. Addams. It consists of a cylindrical boiler 30 in. by 16 in. Five tubes, in a lower row of three, and an upper row of four, traverse the boiler longitudinally. The

Digitized by Google

boiler rests on a frame supported by four glass pillars. Before being placed in the frame, the steam is "got up," by means of an open furnace of a suitable shape; the steam is then "kept up" by a succession of iron heaters, each 15 in. long, which are thrust into the tubes just alluded to; the heaters being prepared in the furnace, after it is vacated by the boiler. A convex cover applied to each end of the boiler after the heaters are in, gives the requisite rounded form. One end of the boiler is furnished with a gauge water-cock and a steam-cock. The boiler also possesses a safety-valve, which is adjusted as high as 90 lbs. Above the boiler rises a short tube furnished with a stop-cock; it enters an inverted hemispherical metal vessel, in which the requisite condensation occurs; from this the hydrated steam escapes through a tube, furnished with the usual box-wood jet. Mr. Addams obtains the electricity of the steam itself by allowing it to blow through an insulated hollow metal cylinder, furnished within with wire gauze or metal points. The spark from the boiler is ten or twelve inches long.

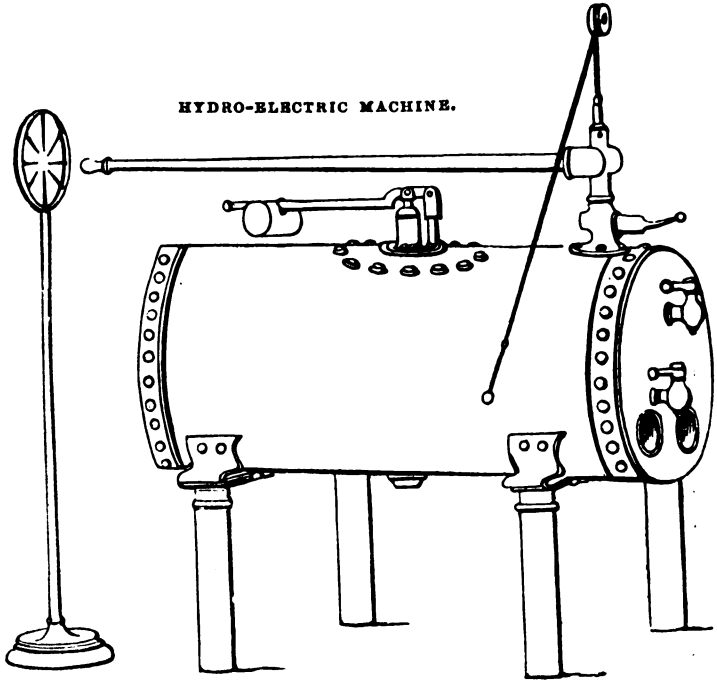
Mr. Gassiot has a small machine, made, under his direction, of a metal globe of the capacity of two gallons,—a globe, which was a gas-holder, in the days of portable gas, and which can therefore bear a high pressure. The steam-tube rises from the top, and curves off at right angles; the jets are fitted up in the usual way. The globe is placed on a small metal tripod, beneath which is a chafing-dish containing charcoal; the whole stands on a square tile, supported by four glass pillars. When in good action, and by careful management, an attenuated spark of an inch may be obtained. Mr. Gassiot exhibited this instrument, and Dr. Pereira exhibited another, constructed after the same model, at the Soirée of the London Institution held on January 17th last.

The annexed engraving represents an elegant machine by Messrs. Watkins and Hill, the general construction of which corresponds with that of the one we first described. The rod, resting on the front of the machine, is a means for conveying the electricity to any piece of apparatus. The circle of converging points, for de-electrizing the steam, was adopted at our suggestion, in place of a mere fork. This machine will charge 70 feet of coated surface in a minute, with 20 grs. on the balance discharger.

We learn from Mr. Armstrong that very great improvements are continuing to be made in the construction of these machines. He speaks of one "capable of charging 110 square feet of coated surface in a minute, to 20 grs. of Cuthbertson's Electrometer, and yet it only discharges as

Digitized by Google

much steam as three of the jets belonging to the great machine at the Polytechnic."* The great improvements appear to consist in having been able more duly to adjust the degree of condensation to the size of the jets. More suitable specimens of partridge-wood have also been obtained. Mr. Armstrong also mentions that the manufacturers are endeavouring to make some, which shall be heated by naphtha lamps. One objection, which may present itself against the use of these machines in a room, is the quantity of steam liberated; but this may easily be carried off by blowing the steam towards a fire, when it will ascend the flue. On the whole, it appears more than probable that the power of these machines may be eventually so modified and exalted, as that they may hold an equal, perhaps a superior rank, to the oft-times troublesome instrument, (for a lecturer especially,)—the frictional machine. In concluding this notice, we cannot help expressing a wish that Mr. Armstrong had adhered to the designation, which he appears originally to have thought



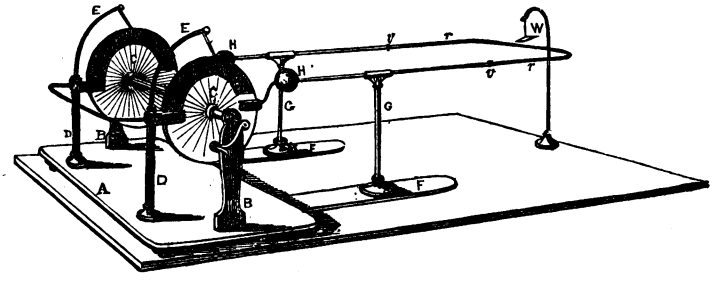
HYDRO-ELECTRIC MACHINE.

* Vide Elec. Mag. page 122.

Digitized by Google

of for this instrument, "Vaporo-electric Machine;"* for by calling it Hydro-electric, it naturally induces many to call the form of electricity it evolves Hydro-electricity, as in the reports extracted into this notice; whereas, that term has long been appropriated to voltaic electricity, which essentially is due to active solutions, as we see it used in this very number of the *Electrical Magazine*, p. 275, in Prof. Majocchi's paper. We should not omit to mention that the machine at the Polytechnic, which is in constant daily use, is in excellent order; and acts as well, perhaps better, than it did at the first.—C. V. W.

XLIV. *The Rheo-electric Machine.* By Mr. JOHN NOTT. Communicated by the Author.



DESCRIPTION.

A.—BASE-BOARD, elevated by four supporters, to permit the sliding pieces *F F* to pass under.

B B.—Uprights, carrying the iron pivots of the axle.

C C.—A circular plate of glass, and another of resin, both supported on an axle of baked wood, and set in motion by the winch handle. The resinous plate must be made as hard as possible, and as brittle as glass. It must be annealed or it will not stand.

D D.—Glass pillars, cemented into wooden bases, and made to slide in and out upon the base-board. The tops of these pillars are furnished with horizontal brass springs, to which the rubbers are attached by brass-pins, so that they may be easily removed, for the purpose of cleaning or amalga-

* Vide Phil. Mag. May and July, 1841.

Digitized by Google

mation. Each rubber is made to bend round the edge of the plate and the springs press on the middle of each lateral portion, so as to equalize the pressure, which is also adjusted by screws, the heads of which are seen in the sketch. The rubber of the vitreous plate is made in the usual way and amalgamated; that of the resinous plate is made of cats'-fur.

E E.—Curved brass-rods, screwed to the caps of the glass-pillars, and, by a silk-cord, attached to the silk-flaps *y y*. The use of these rods is to diminish the friction of the flaps, which must be made to fit the plates, with great accuracy, otherwise they would be strained by their partial adhesion to the plates, in the first instance, so that it would be impossible to work the machine with the regularity of motion that is necessary.

F F.—Sliding pieces, passing under the base-board, *A*, of the machine. The stands of the conductors *H V*, *H V*, are screwed to these pieces: by this means the distance of the conductors from the plates is regulated and the whole instrument kept steady.

G G.—Glass-rods, with wooden caps and cross-pieces, the latter bored to permit the brass-rods of the ball-conductors *H H*, to pass tightly through them.

H H.—Ball-conductors, supported by the rods passing through the cross-pieces. When large accumulations of the electricities are required, these conductors are replaced by ordinary prime conductors. Or, if only one electricity is required, the vitreous, for instance, the resinous-conductor is removed, and then this instrument will generate vitreous electricity as fast as an ordinary instrument twice the size.

P P.—Copper conjunctive wire, bent at right angles, and screwed to the rods of the conductors at *V V*.

W.—Magnetic needle, suspended by a fibre of silk.

In the *Electrical Magazine*, page 132, will be found the notice of the above machine, as described before the British Association. A very full and excellent abstract of Mr. Nott's paper is given in the *Literary Gazette* of Oct. 7th, 14th, 21st, and 28th last. We had wished to have given a very detailed *resumé* of the paper in the present number; but find ourselves compelled to defer it till our next. We conclude this with an interesting extract from a letter from Mr. Nott to Mr. Pollock.—Ed.

"It is well known that the current of the voltaic pile exists within the substance of the Rheo-phore; and, therefore, if the circuit be not interrupted, no interference can take place with this current, except perhaps by heat. It struck me that, as

Digitized by Google

the current of the Rheo-electric machine exists upon the surface of the Rheo-phore, it would interfere with that of the pile. To ascertain the truth of this supposition, I set a voltaic battery in action; and, within the circuit, I placed a galvanometer. At about four feet distance from the galvanometer, there was a mercurial connection. I made the conjunctive wire of the Rheo-electric machine cross this connection at right angles to the voltaic current. The galvanometer indicated a deflection of 35°. As soon as the Rheo-electric current was established, the needle of the galvanometer bounded to 90°, and then returned to the meridian, but never crossed it, and again bounded to 90°, and thus continued to oscillate, with enormous rapidity, across its original deflection as long as the Rheo-electric current was permitted to act.

"Here then we have an alternate increase of intensity and total cessation of the voltaic current, by the mere passage, across its direction, of the Rheo-electric current; establishing a series of interferences of the most remarkable description, and proving to demonstration that electricity passes through the substance of the voltaic rheo-phore, and consequently that electricity is really the principle of the voltaic pile."

SCIENTIFIC MEETINGS.

LONDON INSTITUTION.

Wednesday, January 17th.—This was the first conversazione of the season. Mr. Grove, the Professor of the Institution, delivered his annual lecture on the progress of science during the past year. Electricity held the most prominent place. He mentioned the leading features in the march of electrical research, to which we need not again advert, as our readers have already had them all in full, in the pages of the *Electrical Magazine*. We allude to this lecture here, in order to record the fact that, while mind is being vigorously expended in every class of scientific investigation, and each science is furnishing the due meed of reward to its cultivator, our own science, Electricity, ranks equally with the rest; and, in each revolving year, it adds its full share to the common stock.

Digitized by Google

ROYAL INSTITUTION.

Speculations touching Electric Conduction, and the Nature of Matter. By MICHAEL FARADAY, ESQ., D.C.L., F.R.S., &c. Friday, January 19th, 1844.

Mr. Faraday opened the evening meetings, by delivering what may be termed a very wholesome lecture,—a lecture, that is, in which he endeavoured to draw away the mind from words to things,—in which he raised a warning voice against the too frequent habit of the mind to accept conventional phraseology for actual knowledge. He began by alluding to the received opinion of matter, as for instance, its durability, impenetrability, and so on; and especially in the general constitution of a mass of matter of infinitely small particles compacted into a solid whole. But, as the application of heat increases the size, and as the application of cold decreases the size of any given mass, it has been commonly granted that these said particles are not in either case in actual contact,—that, in the case of a solid body they are very close, and in the case of a gas or vapour, are very far apart. Air, at common pressures, is actual matter; so also is condensed air; in the one case a given bulk contains many more such particles than in the other; and yet the extreme limit is not attained. Under these circumstances, the mind cannot fail to inquire into the nature of the medium which exists between these particles: whether it be something or nothing. But, be it the one or the other, the particles themselves, whether of dense bodies, as the metals, or of light bodies, as the gases, are mutually held together by some force acting across the intervening medium.

Our views of the constitution of matter very soon assume a most complex form, when we enter upon the chemical constitution of compound bodies, and the theory of crystallization; for we here appropriate first the term *atom* to the ultimate indivisible molecule of matter, and then we talk of half-atoms; and of compound atoms, built up of groups of single atoms,—the word *atom*, which is entirely the type of a theory, being made equivalent to *definite proportion*, which is the representation of the fact itself. As an instance of the extreme length to which this system is carried, an atom of bile and one of berberine were instanced,—the one said to contain 110, the other 80 elementary atoms.

With respect then to this constitution of matter, of molecules and intervening space, electricity seemed to be a searching investigator; and its behaviour, with various bodies, promised to solve this intricate problem. On this head we prefer to our own report, Mr. Faraday's words, as given by him in a letter to Mr. Taylor, immediately subsequent to his lecture,*—a letter written to "serve as a record of his opinions and views."

* Vide Phil. Mag., Feb. 1844.

Digitized by Google

"If the view of the constitution of matter already referred to be assumed to be correct, and I may be allowed to speak of the particles of matter and of the space between them (in water, or in the vapour of water, for instance) as two different things, then space must be taken as the only continuous part; for the particles are considered as separated by space from each other. Space will permeate all masses of matter in every direction like a net; except that, in place of meshes, it will form cells, isolating each atom from its neighbours, and itself only being continuous.

"Take then the case of a piece of shell-lac, a non-conductor, and it would appear at once, from such a view of its atomic constitution, that space is an insulator; for, if it were a conductor, the shell-lac could not insulate, whatever might be the relation, as to conducting power, of its material atoms; the space would be like a fine metallic web, penetrating it in every direction, just as we may imagine of a heap of siliceous sand having all its pores filled with water; or as we may consider of a stick of black wax, which, though it contains an infinity of particles of conducting charcoal diffused through every part of it, cannot conduct, because a non-conducting body (a resin) intervenes and separates them one from another, like the supposed space in the lac.

"Next take the case of a metal, platinum or potassium, constituted, according to the atomic theory, in the same manner. The metal is a conductor; but how can this be except space be a conductor? for it is the only continuous part of the metal, and the atoms not only do not touch (by the theory), but, as we shall see presently, must be assumed to be a considerable way apart. Space, therefore, must be a conductor, or else the metals could not conduct, but would be in the situation of the black sealing-wax, referred to a little while ago.

"But, if space be a conductor, how then can shell-lac, sulphur, &c., insulate? for space permeates them in every direction. Or, if space be an insulator, how can a metal or other similar body conduct?"

These views were illustrated by several appropriate experiments; the contradictory inferences are evidently the result of some defect in the premises, of something radically wrong in the molecular theory. Still more conflicting results obtain, when the conducting power of metals is compared with the number of atoms in a given bulk. By dividing the specific gravity of metals by their atomic numbers, the following table is obtained, where the first column expresses the number of atoms in, and the second the conducting power of, equal volumes of the metal.

Atoms.		Conducting power.
1·00	gold	6·00
1·00	silver	4·66
1·12	lead	0·52
1·30	tin	1·00
2·20	platinum	1·04
2·27	zinc	1·80
2·87	copper	6·83
2·90	iron	1·00

"So here iron, which contains the greatest number of atoms in a given bulk, is the worst conductor excepting one. Gold, which contains the fewest, is nearly the best conductor; not that these conditions are in inverse proportions; for copper, which contains nearly as many atoms as iron, conducts better still than gold, and with above six times the power of iron. Lead, which contains more atoms than gold, has only about one-twelfth of its conducting power; lead, which is much heavier than tin, and much lighter than platinum, has only half the conducting power of either of these metals."

Again: on contrasting the conducting power of potassium with

Digitized by Google

the insulating properties of hydrate of potassa, a further series of facts present themselves.

"When potassium is oxidized, an atom of it combines with an atom of oxygen to form an atom of potassa, and an atom of potassa combines with an atom of water, consisting of two atoms of oxygen and hydrogen, to form an atom of hydrate of potassa; so that an atom of hydrate of potassa contains four elementary atoms. The specific gravity of potassium is 0·865, and its atomic weight 40; the specific gravity of cast hydrate of potassa, in such state of purity as I could obtain it, I found to be nearly 2, its atomic weight 57. From these, which may be taken as facts, the following strange conclusions flow. A piece of potassium contains less potassium than an equal piece of the potash formed by it and oxygen. We may cast into potassium oxygen atom for atom, and then again oxygen and hydrogen in a twofold number of atoms; and yet, with all these additions, the matter shall become less and less, until it is not two-thirds of its original volume. If a given bulk of potassium contains 45 atoms, the same bulk of hydrate of potassa contains 70 atoms nearly *of the metal potassium*; and, besides that, 210 atoms more of oxygen and hydrogen. In dealing with assumptions, I must assume a little more for the sake of making any kind of statement; let me, therefore, assume that, in the hydrate of potassa, the atoms are all of one size, and nearly touching each other; and that, in a cubic inch of that substance, there are 2,800 elementary atoms of potassium, oxygen and hydrogen; take away 2,100 atoms of oxygen and hydrogen, and the 700 atoms of potassium remaining will swell into more than a cubic inch and a-half; and, if we diminish the number until only those contained in a cubic inch remain, we shall have 430 or thereabout. So a space which can contain 2,800 atoms, and amongst them 700 of potassium itself, is found to be entirely filled by 430 atoms of potassium as they exist in the ordinary state of that metal. Surely then, under the suppositions of the atomic theory, the atoms of the potassium must be very far apart in the metal, *i. e.* there must be much more of space than of matter in that body: yet it is an excellent conductor; and so space must be a conductor; but then, what becomes of shell-lac, sulphur, and all the insulators? for space must also by the theory exist in them.

"Again, the volume, which will contain 430 atoms of potassium and nothing else, whilst in the state of metal, will, when that potassium is converted into nitre, contain very nearly the same number of atoms of potassium, *i. e.*, 416; and also near seven times as many, or 2912 atoms of nitrogen and oxygen besides."

These and a host of analogous considerations point out the impossibility of getting anything like clear ideas of matter, while it is regarded as constituted of atoms surrounded by space. Mr. Faraday then laid down his own views of matter: he considers that the only ideas of matter, which are warranted by observed facts, are that it consists of *centres of force, surrounded by atmospheres of power*, or, as he expressed it in the letter from which we have quoted, "merely of centres of force, having powers attached in and around them." In his view, the atoms of gases touch each other, just as truly as do those of liquids or solids; the centres of the force may indeed vary in their distance, but these alone are not the matter; the power, which is the very essence, the eternal accident to these forces, is continuous throughout. On this point, he thus expresses himself:—

"Hence matter will be *continuous* throughout; and, in considering a mass of it, we have not to suppose a distinction between its atoms and any intervening space. The powers around the centres give these centres the properties of atoms of matter; and these powers again, when many centres, by their conjoint forces, are grouped into a mass, give to every part of that mass the properties of

Digitized by Google

matter. In such a view, all the contradiction, resulting from the consideration of electric insulation and conduction, disappears."

The mind needs not the shape or size of the atom in order to complete this idea; these properties can be entirely abstracted. These views lead to what may at first seem a startling inference,—one quite at variance with our old prejudices, viz., that there exists a *mutual penetrability of matter*. This seems more than warranted by the experiments with the potassium; yet it cannot be received by a mind pre-occupied with the old theory. But, when the doctrine of centres of power is accepted, it is far from difficult to believe in the coalition of two such centres; in this view, if "two atoms be centres of power, they will mutually penetrate to the very centres, thus forming one atom or molecule with powers, either uniformly around it, or arranged as the resultant of the powers of the two constituent atoms." Another obvious inference is that matter pervades space;—the sun, the earth, the planets, being in mutual contact; for the powers are mutually active. Into the extensive bearings of the subject, Mr. Faraday did not pretend to enter; he had said thus much in order to rouse the mind from its unfortunate habit of dwelling so long on conventional terms and recognized theories, as to take them for actual knowledge.

On the Progress made in the Application of Electricity as a Motive Power. By W. R. Grove, Esq., M.A., F.R.S., &c. Friday, February 9th, 1844.

His object was to review the various applications of the electro-magnetic force, which have been made since its first discovery by Œrsted in 1819, and first application to actual rotary motion by Faraday. After explaining and illustrating by many novel experiments, the character and direction of the force exercised by voltaic currents upon magnets, Mr. Grove pointed out three definite ramifications of the force which experimentalists had sought to apply to the practical production of mechanical motion. 1. The immediate tangential or deflective power of the current which is shown in the ordinary galvanometer, where a magnet is deflected by a stationary wire, affected by a voltaic current; and in the revolving wheel of Barlow, where the radii are deflected and revolve by the influence of a stationary magnet.—2. What is called the suspension principle, where powerful stationary electro-magnets are made to attract pieces of soft iron placed in the periphery of a wheel. As each piece arrives opposite the magnet, the voltaic current is interrupted by the revolution of the wheel itself, and this passes on until the next piece comes within the influence of the magnet, which being re-electrized, again attracts, and so on in rotation.—3. The principle of inversion of polarity first introduced by Dr. Ritchie. In this two sets of magnets are employed, the one set stationary, the other rotary; the poles of the last being alternately charged by inversion

Digitized by Google

of the voltaic current, the attractions of the two opposite poles of powerful magnets are rendered available.

"Beautiful working models of the application of the several principles were exhibited, most of them representing patented machinery.

"Mr. Grove then entered upon the statistics of expense of electro-magnetic machines. It appears, from the experiments of Dr. Botto of Turin, that the consumption of 45 lbs. of zinc is necessary to work a one horse-power magnetic machine for twenty-four hours. Dr. Botto worked with Mr. Grove's battery, against which, although admitted to be by far the most powerful, and equal in constancy to any other form, a general notion prevails that it is expensive. This, Mr. Grove says, is not the case, and gave his reasons as follows:— to contrast the cost of the nitric acid in Grove's battery with the apparently cheapest form, namely, a battery charged with dilute sulphuric acid only: this latter, to overcome a given resistance, say to decompose an equivalent of water, requires a series of at least three cells, while only *one* of the nitric acid battery is requisite. Hence we have in the first, three equivalents of zinc, and three of sulphuric acid consumed; in the second, one of zinc, one of sulphuric acid, and one-third of nitric acid; for nitric acid having five equivalents of oxygen, three of which are actually available, does three units of work. The calculation then becomes, as given in the annexed table:—

Chemical equivalent of zinc, 32.
Chemical equivalent of nitric acid, 54.
$54 \div 3 = 18$.
$32 : 18 :: 45 : 25{\cdot}3$.
45 lbs. of zinc at $3d. = 11s.\ 3d.$
25·3 lbs. of real (*i. e.* 50·6 lbs. of commercial) nitric acid, at $6d. = £1\ 5s.\ 7\frac{1}{2}d.$
$11s.\ 3d. + £1\ 5s.\ 7\frac{1}{2}d. = £1\ 16s.\ 10\frac{1}{2}d.$, the expense of one-horse-power for 24 hours.

"In this, the small expense of the sulphuric acid, and minute waste of mercury are thrown out of the equation, as more than balanced by the salts, formed during the action of the battery.

"It is evident from this that the expense of electro-magnetic machines far exceeds that of steam: indeed, it could hardly be expected to be otherwise, as, with the one we use, for fuel, manufactured materials, in the production of which, coals, labour, &c., have been expended; in the other, coals and water are used directly. This is rather discouraging; but, at the same time, we must remember, that in magnetic motion, nothing is wasted; when the machine stops, the consumption stops also; and Mr. Grove thinks that we should not so much direct our endeavours to rival steam, as to find out methods of application where steam cannot be applied. The telegraph is one of these, and probably some others will be found; at all events the idea that so much ingenuity, labour, and perseve-

Digitized by Google

rance should have been applied, and should have marched with rapid strides in vain, is contradicted by the whole history of science; and though it may not be easy to point out the exact where, when, and how of its success, still, considering the enormous progress of electro-magnetic applications made within the last few years, there is every ground for hopefulness as to its ultimate success."—*Lit. Gaz. Feb. 17th*, 1844.

REVIEWS AND NOTICES.

Electrical Experiments, &c., with numerous illustrative Engravings. By G. FRANCIS, F.L.S. Berger, Holywell Street, 1844. 8vo., pp. 92.

A USEFUL manual, especially for the young electrician, containing a large mass of experiments in Frictional Electricity, arranged in due gradation from the first simple case of excitation of amber, to the last addition to this science,—the hydro-electric machine. The young aspirant after electrical knowledge, whose desires are deeper than his pocket, will find here ample instructions, evidently the result of experience, to enable him to construct for himself many of the essentials for prosecuting this study. The lecturer can glance through the volume with advantage, as it may remind him of the existing experiments for illustrating particular points, and of other experiments, which are in a fair way of becoming obsolete, through the hurry and bustle which is urging us all onward in pursuit of "some new thing."

There are many original experiments; and many others, that we had almost forgotten. The author has collected industriously from all quarters:—*The Electrical Magazine* has been a contributor. Each class of experiments is preceded by a descriptive account of the special points, which they are fitted to illustrate. In other respects, the book, for the most part, preserves its character of being a collection of experiments. Occasionally, however, the author enters a little into the science; as, for instance, when contrasting two classes of electric development, he says;—

"In electrical experiments, we see attraction and repulsion take place between the bodies excited; in galvanism, there is nothing of the kind apparent. Electricity has very little effect in causing chemical decomposition—galvanism does this by the simplest combination."

This passage is philosophically incorrect, although the author does not intend it; for, as we well know, the effects of each kind, —but we are wrong in using the word *kind*, for a modification of the same thing;—each development of electricity is productive

Digitized by Google

of analogous phenomena,—phenomena, essentially the same, differing only in degree. We point this out, as we are anxious that, while a broad line may be drawn between the mechanical adjustments, which regulate the production of electricity, the eternal oneness of the thing produced,—if indeed it be a thing, and not a power,—may be kept prominently in view.

We cannot forbear making the following extract, which expresses a fact often lost sight of, and which, in a measure, accords with our own views, elsewhere expressed:*—

"It will have been observed, that, wherever we have shown friction, there has also been separation of contact; and, upon a strict examination, it will be found, that although the rubbing of two dissimilar bodies together may and does occasion the electric fluid to be disturbed, yet it is only when these bodies are held apart that each is found to put on electrical appearances."

In one experiment, in which spots of tin-foil are glued on a dry deal board, the author says:—

"We have by this means sent the shock of a gallon Leyden jar through an extent of 180 feet, illuminating four boards with the words 'Good night, all 's well,' in well proportioned letters, thirteen inches high; and by the same shock also rendered luminous 300 feet of iron chain, and fired a bladder of gas in the distance."

The whole amount of these experiments is 417; enough, in all conscience, to include every feature of the science, and to satisfy the most fastidious tyro. The volume concludes with a short chapter on Medical and Animal Electricity, and another on the Hydro-electric Machine.

On the Damage which has occurred in the British Navy by Lightning, with an Account of the attendant Phenomena: abstracted from the Official Journals of the respective Ships, and from other authentic sources of information. By W. Snow Harris, F.R.S., &c. From the *Nautical Magazine*, 1843.

Mr. Harris has commenced a series of papers in the "Nautical Magazine," which are to include "An Authentic List of some of the ships of H. M. Navy, struck and damaged by lightning at various times, with brief notices of the attendant Meteorological and other Phenomena." "In describing these cases the following arrangement has been adopted, with the view of facilitating scientific and statistical deductions from them. 1st, the place of the ship is given with the date. 2ndly, the effects of the discharge. 3rdly, the meteorological phenomena. Lastly, such remarks as appeared necessary to complete the history of the case." The ships are arranged in alphabetical order; and, in the portion of the list before us, terminate at the "Glatton," being No. 55 of the series, which will extend considerably beyond 174, the number included in the "Nautical Magazine" of 1838. We look with anxiety to the completion of the series, because the author pur-

* Vide Cabinet Cyclopædia.—Electricity, vol. ii. p. 310-13.

Digitized by Google

poses entering on a critical examination of the phenomena it presents, with the prospect of being able to deduce some general laws.

Anweisung zur Vergoldung und Versilberung auf Galvanischem Wege, &c. Instruction in Gilding and Silvering by the Galvanic Mode. By F. WERNER. St. Petersburg, 1842. Dedicated to H. E. Count Cancrin. 8vo. stitched, pp. 18.

The solutions described by the author are the double cyanides. Mr. Briant of St. Petersburg, whose recipe he follows for the gold solution, adopts a somewhat different plan to that practised by Messrs. Elkington, which he states is far preferable. In the silver solution he follows Major Von Jewreinoff, who prepares it with chloride of silver dissolved in the simple cyanuret of potassium procured by Liebig's process. A variation is given in the form of the generating apparatus; but it is perhaps no improvement on those with which we are familiar.

Electrotype Manipulation.—Part I. *being the theory, and plain instructions in the Art of Working in Metals by precipitating them from their solutions, through the Agency of Galvanic or Voltaic Electricity;* Thirteenth Edition. Part II. *containing the history, and plain instructions in the Arts of Electro-plating, Electro-gilding, and Electro-etching; with an account of the mode of depositing Metallic Oxides, and of the several applications of Electrotype in the Arts.* Seventh Edition. By CHARLES V. WALKER. London: Knight and Sons, Foster Lane, Cheapside. 1843.

Although from our own pen, we shall not hesitate in including these manuals in our notices of new works on Electrical subjects. It is true they have been for some time in the possession of the public; but, since the first number of the *Electrical Magazine* appeared, new editions have been demanded; and the great improvements and additions which the art of Electrotype has undergone compelled the author almost to re-write them, especially Part 2., which is in effect a new treatise compared with the first edition. Our readers must pass their own judgment on them.

Noad's Lectures on Electricity.

(SECOND NOTICE.)

WE cannot help sitting down in most good-natured mood to review this book: the author has said so many kind things of ourself in many of its pages, and also of *The Electrical Magazine*, that we should be forced, even were it in spite of ourself, to give him the best word we could command. We must, however, do our endeavour to banish these influential thoughts, and take the volume

Digitized by Google

on its own merits. It is called *Lectures* on Electricity,—Lectures, we presume, "lucus à *non* lucendo;" for, assuredly they never *were* delivered, nor is it likely they ever *would be*. They are essentially things to be *read*, not things to be *heard*. We say this commendatory, and not condemnatory of them, thinking it almost a pity that a treatise like this should come before the public under so inappropriate, and so unpopular a name. We know, from long experience, that no title is so repulsive—to the young aspirant, at least, as Lectures. This volume is the second edition to a small octavo book, which the author published some years ago under the same title. In his present preface, he says, referring to the former edition, "I have, therefore, so completely revised it, that the present volume may be considered a *new work*, bearing but little resemblance to the last, except perhaps in its popular character." Would it not have been well to have rendered the reformation complete, by giving it a new name,—its true and proper title?

And now of the work itself. We have already given a sketch of its matter,* and our present observations shadow out our generally favourable view of its manner. But we must be more minute. Lecture I. gives a short sketch of the history, and explains very clearly the leading phenomena of Frictional Electricity. We here find an account of Dr. Bird's *Electrolasmus*, not generally known:—

"A very useful modification of the Electrophorus of Volta is made by coating a thin pane of glass on one side with tin-foil to within about two inches of the edge; placing it with the coated side on the table, the other side is to be excited by friction by a piece of silk covered with amalgam; then, carefully lifting the glass by one corner, place it on a badly conducting surface, as a smooth table, or the cover of a book, with *the uncoated side downwards*. Touch the tin-foil with the finger; then carefully elevate the plate with one corner, and a vivid spark will dart from the coating to any conducting body near it; replace the plate, touch it, then again elevate it, and a second spark will be produced. By this means an electric-Leyden jar may speedily be charged."

The second lecture is a very successful reflex of the investigations of Faraday, especially on the phenomena of induction, discharge, and so on. The author has obtained clear ideas of the discoveries of that great philosopher, and has expressed them in happy language. In page 51, he gives Mr. Lockey's mode of preserving Leyden jars from fracture. He gives in this, as indeed he did in the preceding lecture, a set of illustrative experiments. He presents also a good *resumé* of all that has been done on the subject of true polar decomposition by static electricity.

The lecture on Atmospheric Electricity includes a detailed account of kite experiments, together with Mr. Crosse's and Mr. Weekes' atmospheric apparatus. A magnificent and most astounding electrical display, which occurred to the former gentleman during a November fog, is given in full. We are sorry that we have not space for the extract. Paragraph 165, on evaporation, may possibly receive some modification, now that the hydro-electric

* Vide Elec. Mag. p. 228.

Digitized by Google

machine is understood. The author has very candidly examined the case of lightning conductors and vicinal connections: he sides rather against ourselves in the text; but, in the appendix, he does not appear to press his decision.

The three following lectures are devoted to voltaic electricity, and are compiled with very considerable labour and with great success. They contain a rich collection of the leading facts in this ever expanding branch of physics. The voltaic theories are treated on at great length, and with impartiality. Electric fish are described; so are the Acari Crossii. Mr. Crosse's famous experiments on crystallization, together with several new ones, are given. We may here make an observation, applicable to the volume throughout;—that it contains, each in its proper place, many very interesting experiments in the several branches of the science, which are either new, or are not generally met with. The phenomena of passive iron are very diligently detailed, and the author's own experience, on this curious condition of the metal, is given. The following experiments, by Mr. Crosse, are novel:—

"1. A common garden-pot full of moistened pipe-clay was placed in a basin full of water: a platinum wire, connected with the negative extremity of a sulphate of copper battery, of twelve pairs of plates, each two inches long, by one inch wide, was placed three inches deep into the middle of the clay; and a second platinum wire, connected with the positive pole, was plunged into the water in the basin, to the same depth. Within a fortnight, *fissures* took place in the clay in contact with the negative wire; and, in six or eight weeks, these fissures filled with water, which was drawn up two inches above the level of the water in the basin. A small pool of water was formed round the negative wire, which at last overflowed, and trickled constantly into the basin below. Here then was a *constant electrical spring.*"

"2. Here the experiment was varied; but the apparatus was precisely similar. In this, both wires were plunged three inches deep into the same pot of moist pipe-clay, at the opposite sides, but about three-quarters of an inch from each side. Within a fortnight, fissures took place at the negative, but none at the positive wire. In a month or six weeks more, these fissures filled with water which overflowed, and so on, being apparently acted on by change of weather. Mr. Crosse generally found the spring overflowing, when the barometer was *very low;* and the reverse, when it was *high.* Here then was an electrical *intermittent spring.*"

This is one out of many passages, interspersed throughout the book; it is taken as the type of a class, and we might fill pages with other such, all of them interesting to our readers, from their novelty, and their influence on particular points in the science: but we must forbear in our work of spoliation. Let our readers imagine magnetism, electro-magnetism, and magneto and thermo-electricity equally well enriched with new things, as well as with the good old standard facts, that have borne the test of time, and they have the general character which pervades the whole.

We can anticipate one question, which cannot fail to rise in the minds of many,—is the general tenour of the volume *didactic* or is it descriptive? Descriptive certainly. The didactic character does at times pervade its pages, but in most cases it merges soon into the other; at any rate the other predominates. No one, who reads this volume, and it is a great thing in its favour, can fail in com-

Digitized by Google

mending the modest manner in which the author puts forth everything pertaining to himself; — although he has not been an idle electrician, yet he nowhere, throughout his work, intrudes his own pretensions; when he has occasion to allude to himself, it is done in the least assuming manner possible; and yet without design. He collates the works and thoughts of others; he condenses them or dilates upon them, as the case may be, and does his best to give a faithful picture of electricity as it is, without standing as judge to decide the ever-existent, and, as we can imagine, the ever-to-be-existing differences, which vex and will vex the philosophic world.

On the Application of Electro-Metallurgy to the Arts. By Elkington and Co., London. Fcap. 8vo., pp. 32, wood-cuts.

The patentees have *put forth*, we must not say, *published*, for it is printed for their customers and others,—a little pamphlet, which may not inaptly be termed, "An Apology for Electro-Plating, &c.," in which the several advantages connected with this branch of industry are set forth in order. We see that Mr. Warrington has submitted an electro-plated capsule to a very severe test, and it stood it well. The best evidence in favour of the domestic value of these goods is given thus:—

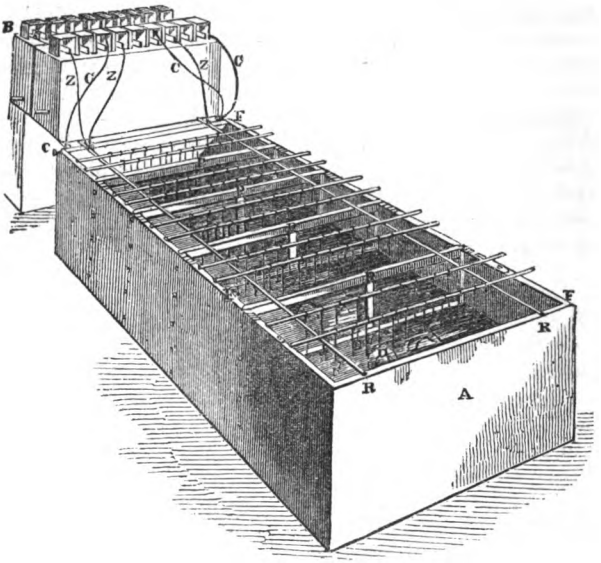
"We find that those interested in opposing the progress of this art have not been slow in urging as an objection, what may be said of every new invention —that it has not experienced the test of time; but to this we reply, by referring to the first extensive order we received, viz., in 1841, for the supply of the steam vessels of the Royal Mail Steam Packet Company. These goods, including the whole supply of forks and spoons, are much approved, and have endured a wear equal to nine or ten years in domestic use."

In *The Electrical Magazine*, p. 151, we noticed that the law of France had decided in favour of Messrs. Elkington's patent right in that country. We see that the tedium of a law suit against the Count de Ruolz has been avoided by a compromise:—

"In consequence of the extended litigation we had experienced with our former patent, we had done little more at the beginning of 1841, than exhibit the process, and produce specimens of our electro-gilding to some of the members of the Royal Institute. Meanwhile, the Count and his friends had written a great deal, and had partly completed extensive arrangements to work the process itself. No doubt, we should have established our precedence; but one suit in a foreign country of nearly five years' duration was little encouragement to that course; and having been strongly advised by some members of the Royal Institute to effect a union of the patents, we at once negociated terms, &c."

We must not omit to mention that the pages contain a general account of the process of electro-metallurgy, and possess a few hints not to be found elsewhere. Our readers may feel curious to know how these things are done on a large scale. We give the method just as it is at the present moment being conducted at their place in Moorgate Street:—

Digitized by Google



"A, vat or vessel containing the solution; B, battery, with zinc pole, Z, connected with rods, R, R; and copper pole, C, connected with the metallic sheets, P, P, in the solution by the copper slip, F; D D, are articles suspended in the solution by wires from the rods, R R; S, the solution."

Fancy these articles to be dishes and salvers, and covers, &c., an idea of the size of the vessel is gained. We have not much to say in favour of the philosophy of the description of Electrolysis. The mitigating motto, "*Ne Sutor*, &c.," can scarcely be urged in extenuation. This part of the subject, however, belongs more to the philosopher: he has given the theories, and seen and suggested the results to which they would lead; the manufacturer has taken the matter into his hands, and has shown what the other only suggested.

Descriptive Catalogue of Electrical Instruments and Apparatus: 97 *wood-cuts; of Voltaic and Thermo-Electro Apparatus:* 78 *wood-cuts.* Watkins and Hill. 1844. Two Pamphlets in 8vo. pp. 14 and 15.

The catalogues of our philosophical instrument-makers are always acceptable additions to the scientific library. They let us know of those forms of apparatus which are most in vogue for the time being; and they show us the march of improvement in instruments, and the forms under which the various apparatus are introduced into the market. There are two improvements possessed by these catalogues; the first is, that each branch of science has a separate pamphlet; and the second is, that we have here the first well-

Digitized by Google

made attempt to give a *descriptive* catalogue. On this latter account alone do they become books properly so called; and as such, come under our notice. Each instrument is accompanied by a short letter-press description of its nature, its importance, and its uses. The plan of reference adopted in Part I. has been improved upon in Part II.; so that by comparing any paragraph with the drawing bearing the corresponding number, or *vice versâ*, a general idea of the instrument and its uses is obtained. We feel that our duty would have been neglected had we let these little publications pass through our hands without notice; because each of them contains a great number of facts which are worth having thus ready at hand. There is a very useful form of voltaic battery given in Part II., p. 6, a description of which was first given in the Proceedings of the Electrical Society, p. 113, and afterwards in Electrotype Manipulation, part II., p. 35.

NEW BOOKS.

Electrical Experiments, by G. Francis, F.L.S., 3*s.*—*Year-Book of Facts in Science and Art, for* 1844, 5*s.* — *Archives de l'Electricité, Nos.* 11 & 12, *by De la Rive.*—*Sur l'Emploi de la Boussole dans les Mines, par A. Quetelet.* — *On the Connexion of Geology with Terrestrial Magnetism, by Evan Hopkins,* 10*s.* 6*d.* —*Magnetisme Terrestre, &c., under the auspices of Admiral Duperré, by M. de Freycinet,* 1842, 4*to.* — *Annales de Chim. et de Phys. t.* 9, *Dec.* 1843, *t.* 10, *Jan.* 1844, 8*vo. &c.*—*Traité des Phénomènes électro-physiologiques des Animaux, par M. Ch. Matteucci; suivi d'Etudes anatomiques sur le système et sur l'organe électrique de la Torpille, par M. P. Savi,* 1844, 8*vo.* — *Traité de Physique considérée dans ses rapports avec la Chimie et les Sciences Naturelles, par M. Becquérel, tom. II.* 8*vo., avec planches en* 4*to.,* 1844. — *Rapport Annuel sur les Progres de Chimie, &c., par M. Berzelius; traduit du Suédois par M. Plantamour,* 1844, 8*vo.* — *De l'Electricité en général et de ses applications; par MM. Galetti et Jouain,* 1844; *brochure,* 8*vo.*—*Annals of Meteorology and Terrestrial Magnetism, (German,) by M. Lamont, Munich,* 1843; 8*vo.*—*Watkins and Hill's Catalogue of Electrical Instruments,—and of Voltaic and Thermo-Electric Instruments,* 1844, 8*vo.*, 6*d. each.* — *Observazioni sui Parafulmini del Prof. Ferdinando Elice,* 1843, 8*vo.*—*Relazione storico-critica sperimentale sull' ellettro-magnetismo del Prof. Zantedeschi,* 1840.

Digitized by Google

NOTICES OF EXPERIMENTS, &c.

SUCCESSFUL PROGRESS OF ELECTRICITY AS A MOTIVE POWER.*

"Sometime since, I sent, through your hands, to the London Electrical Society,† a short notice, translated from the *Augsburg Gazette*, to the effect that Wagner, of Frankfort-on-the-Main, had very nearly completed his electro-magnetic carriage. The some paper now announces, Dec. 3rd, 1843, (and the Correspondent gives his name, Beil) that the carrriage is now complete, and only awaits the examination of the commission to be named by the German Diet. The arrangement appears to be capable of great power, for the carriage (with machinery producing the motion and the battery,) weighs a ton and a-half. The description is very incomplete; but from what is said of the carriage being mounted 'on ordinary rail-road wheels,' it appears not to be destined for use on common roads. The battery consists of twenty pairs of copper and zinc plates. Mr. Beil says experiments have already shown that the arrangement has sufficient power to propel, with the greatest facility, the carriage containing from thirty to forty persons. Nothing is said of the velocity attained in these experiments. By this time twelvemonth the affair will, I suppose, be settled one way or the other.

"A Berlin paper, dated about the 29th of November last, contains a letter to the following effect:—'Bauer of Nuremberg at present shews a machine, which convinces all those who see it, that the magnetic force may be carried to any extent that is desired. The machine is of peculiar construction:—attached to an upright iron spindle, there is a wheel of the same metal; below, there are numerous moveable magnets having motion imparted to them by a large magnet. The method of inverting the poles is quite original, being totally different from the method of Jacobi.

* The present number was nearly made up, when this interesting communication reached us, on which account we are compelled to place it where it now stands.—Ed. *Elec. Mag.*

† Vide Proceed. Elec. Soc., p. 438.

Digitized by Google

The battery, which, however, one does not see, must be of great energy. The wheel preserves an uniform velocity of motion. The machine is employed in pounding spices, and it is well finished, and strong in all its parts.' "—*Extract of a Letter from Mr. Lettsom to Mr. Weekes, and communicated by the latter to the Editor.*

Effects of Lightning.—My house was struck by lightning a few weeks ago during a violent rain. The electric fluid followed a spout filled with water, into a cistern, out of which a stream was flowing, thus affording a conductor to the earth. Yet the outer circumference of the cistern was torn into splinters, the fluid having passed outward through the staves. The largest splinters extended from one to another of the iron hoops of the vessel, which were slightly fused at a number of points.—Extract of a letter from S. S. Haldemon, Esq., dated Marietta, Pa, Sept. 15, 1843. —Vide *Silliman's Journal*, Jan. 1844.

Variation and Dip at Nantucket, Massachusets.—By a series of careful experiments, made in the autumn of last year, Mr. William Mitchell determined the mean variation to be 9° 09′ 59″ west; and the mean dip, 73° 41′·25″.—*Silliman's Journal*, Jan. 1844.

EPIGRAM ON THE "MATTER."

"Great Faraday, a few days back,*
The laws of matter did attack
With wondrous hardihood.
In vain our notions, he uproots;
When Faraday the subject moots,
The matter's always good.

Literary Gazette, Jan. 27th, 1844.

Accident by Lightning.—Of the accidents which happened on the morning of July 28th, 1842, when St. Martin's steeple was struck, there is one deserving of record, from the peculiar feature it presented. A few hundred yards from the Thames, on the Middlesex shore, and about half a mile above Vauxhall Bridge, is a very elevated chimney of a white-lead manufactory; it rises from the centre of a court-yard, (beneath which the furnace-flues pass,) and at some distance from the main buildings. It is not furnished with a lightning-rod. The top is finished off with immense masses of iron, forming the mouth of the chimney. The lightning struck the iron, and then, through the influence of clamps contained in the brick-work, it committed sad havoc with several of the corners of the chimney (which is octagonal). From the relative position of the parts damaged, it was evident that, in its passage downward,

* Vide Elec. Mag. p. 295.

Digitized by Google

the lightning pursued a spiral path, as though influenced by two mechanical forces; for the point first touched was almost on the opposite side to that last touched; and the intermediate points were at the angles between these. We examined the damage immediately after the accident, and were much struck with this fact.—[Ed.]

Electro-Plating and Gilding.—Mr. E. Tuck has taken out a patent for plating, in which he claims the use of either the sesqui-carbonate or the bi-carbonate of ammonia as one of the ingredients in the solution. He varies the salt of silver according to the nature of the metal or alloy to be plated; for the common kinds of German silver, he uses the sulphate of silver; but for the superior kinds, and for copper, he uses the cyanide of silver. He prepares a solution of seventy parts by weight of bi-carbonate of ammonia; and to this he adds 156 parts by weight of sulphate of silver, or else 134 parts of cyanide of silver, these being equivalents; and he *boils the liquor* till the salt of silver is entirely dissolved. He varies the strength of the solution according to circumstances; the strongest he has had occasion to use contained half an ounce of bi-carbonate of ammonia with 107 grs. of sulphate of silver to a pint of water.

— Mr. Woolrich has patented the following preparations:—He boils twenty-eight pounds of pearl-ash in thirty pounds of water; to which, when cool and filtered, he adds fourteen pounds of distilled water, and then saturates the solution with sulphurous acid gas, producing thus sulphite of potash, which he terms *the solvent.* He now dissolves twelve ounces of crystallized nitrate of silver in three pounds of distilled water; and adds the solvent as long as a whitish precipitate falls: the precipitate is then washed, and re-dissolved in a sufficient quantity of the sulphite, to which is added one-sixth part more, so that the solvent may be in excess: this he calls the *silvering liquor.*

— For *gilding*, he dissolves four ounces of fine gold in eleven fluid ounces of nitric, thirteen of muriatic acid, and twelve of distilled water; the solution is evaporated, and the crystals are re-dissolved in one pound of distilled water. The gold is then precipitated by pure magnesia; the precipitate is first washed with distilled water, acidulated with nitric acid, and then with water alone. To the washed precipitate is added enough solvent to dissolve it, and one-fifth more.

— A *coppering* liquor is prepared by dissolving seven pounds of sulphate of copper in thirty pounds of distilled water, and adding solution of carbonate of potassa till precipitation ceases. The washed precipitate is dissolved in the solvent, with one-third more than enough.—[Ed.]

Ozone.—Prof. Schœnbein has just written a reply to M. de la Rive's opinion that the electrical odour is not due to a something liberated from union with hydrogen, as Schœnbein thinks, but rather to metallic particles detached in the form of oxide from the

Digitized by Google

conductor, whence the electricity emanates. The arguments in the reply are chiefly based on the similarity of the odour, whatever be the metal, and also on its occurrence when wood is used : he agrees, however, with M. de la Rive, that the existence of ozone will not be completely free from doubt, until it shall have been obtained in an isolated form. The latter philosopher purposes again reverting to the subject, when any facts shall have been gathered, calculated to elucidate it. For the present he limits himself to declaring that without in the least degree binding himself to his hypothesis, he still thinks it the most reasonable, and the most in accordance with observation. He does not deny, on his part, the force of some of Prof. Schœnbein's objections examined in detail, but he still persists in believing his hypothesis more probable than the other; "for it rests on the existence of known facts, while the hypothesis of ozone is based on the existence of a body quite new, of a very peculiar nature, and which can be perceived neither by a near nor a distant examination, except by the odour which it is admitted to possess."—*Archives de l'Electricité*, 18 *July*, 1843.

Black as a conductor.—M. Sellien has addressed to the French Academy several remarks on the efficacy of black bodies to draw off electric fluid from the clouds without explosion; he compares their action with that of ordinary lightning-rods, which, when they surmount very elevated edifices, are frequently struck with lightning.—*Compte Rendu*, 17 July, 1843.

Frictional Electricity.—"From the facts observed by M. Peltier, it follows that pressure and swiftness are uninfluential on the effects produced; and that the quantity of electricity is in proportion to the swiftness, whatever the pressure is. In the explanation which this philosopher has given of facts observed, he has deducted the electricity which recombines at the very source where it is liberated, when no obstacle to this recomposition is present. It is for want of having made allowance for this recomposition, that other persons have been equally led into error in the explanations they have given of the phenomena produced in the liberation of electricity by friction; in fact, the following considerations ought never to be lost sight of:—1st, when the decomposition of the two electricities by friction is brought about more rapidly than the recomposition, the electric tension increases. 2nd—if the recomposition is made in an appreciable space of time, the faster we turn, the higher will the maximum tension arise. It is very evident that, when we turn rapidly, a certain point is attained at which the tension of the liberated electricity is such that a portion of the two electricities combines, notwithstanding the bad conductibility of the bodies rubbed; the same will be the case in proportion as the intensity increases. Hence, there must be a certain maximum intensity, which cannot be passed, seeing that the two electricities always recombine on contact, the friction not being so instantaneous, that the separation of the two bodies can be effected in an infinitely small space of time. Whence we may comprehend that the disen-

Digitized by Google

gagement of electricity is independent of the pressure, and of the swiftness of the friction."—BECQUEREL, *Traité de Physique, &c.*, p. 406.

Blasting by Electricity.—The "Dovor Chronicle" reports that Mr. R. W. Thomson, a young Scotch engineer, has been lately engaged in experiments for exploding gunpowder by Leyden discharges. He avoids hygrometric effects by enclosing his machine and battery within an air-tight box, containing chloride of calcium, so that he is not dependent on the varying conditions of the atmosphere.—ED.

Gas light Superseded by Electricity. —"A letter from Paris, dated Oct. 21, gives the following interesting account of the first public trial of an experiment which has been more than four years in preparation, for fixing at a public point the electric light, and making it applicable to the purpose of lighting the streets and private houses:—On one of the bases of statues called the Pavilion de Lille, on the Place de la Concorde, a glass globe, of apparently twelve or thirteen inches diameter, with a movable reflector, was connected with a voltaic battery, and at a little before nine o'clock the electric light was developed in it by proper conducting arrangements. At this time all the gas-lights of the Place, about 100 in number, were burning. As soon as the electric light appeared, the nearest gas-lights had the same dull, thick, and heavy appearance, as oil-lamps have, by the side of gas. Soon afterwards the gas-lights were extinguished, and the electric light shone forth in all its brilliancy. Within 100 yards of the light it was easy to read the smallest print; it was in fact as light as day. The astonishment of the assembled multitude was very great, and their delight as strong as their astonishment. The estimate made by scientific persons who were present, was, that the electric light was equal to twenty of the gas-lamps, and consequently, that five of these lights would suffice to light the whole Place most brilliantly. As regards the expense of production, nothing positive has transpired; but I think I may safely assume that it would be considerably less than that of the generation of gas, whilst the first outlay for machinery and conductors would not amount to a twentieth part of that required for gas-works. There would also be another great advantage in the electric light. It gives out no bad smell; it emits none of those elements which, in the burning of gas, are so injurious to health; and explosion would be impossible. The only danger that would arise, would be at the battery itself, but that would be under the control of competent persons; and even in this respect there would be no danger, even to unskilful persons, with an apparatus of moderate size. Internal lighting would be as practicable as external lighting; for by conductors the fluid would be conveyed to every part of the house. The experiment performed last night was with a voltaic battery of two hundred pairs, composed as follows:—1st, an outer cylinder of glass; 2ndly, in this cylinder a cylinder of charcoal, open at both ends, and plunged in nitric acid contained in

Digitized by Google

the outer cylinder; 3rdly, in the cylinder of charcoal a porous porcelain tube, containing water acidulated with sulphuric acid, and within the porcelain tube a cylinder of amalgamated zinc plunged into the acidulated water.* The pile was on the Pavilion de Lille; the two copper conductors from the two poles, terminated in charcoal points, within the globe, from which the air had been exhausted. The electricity produced a soft, but most intense light. I understand that the experiment was considered highly successful by the authorities who were present, and that it is to be repeated on a larger scale. Should the thing work as well in a general way as it did last night, and the cost be less than that of gas, which it must be, there will be a dreadful revolution in gas-works. I have heard it asserted by persons who are acquainted with M. Achereau, the gentleman who performed the experiment last night, that a company for the supply of the electric light would realize a handsome profit on charging only a sixth of what is now paid for gas. The strength of the electric light did not appear to me to exceed that of the hydro-oxygen; but it is much more simple in the apparatus required, and much less costly in the expense of production. The hydro-oxygen light requires double and most expensive apparatus, and is only applicable to a few localities; the electric light may be applied externally and internally in any place."—*Extract, with verbal alterations, from the daily papers.*

Equivalent of Zinc.—M. Favre has subjected oxalate of zinc to very careful analysis; the mean result of four experiments gave 33·01 as the equivalent number. By another method, which consisted in passing the hydrogen evolved by zinc from acid water, over incandescent copper, he obtained 32·991; from which experiments, he considers 33 to be the equivalent.—*Compte Rendu*, 20 Nov. 1843.

Terrestrial Magnetism.—M. Aimé has communicated to the French Academy the general results of a series of magnetic observations made at Algiers, during nineteen consecutive months, according to the plan proposed by the Royal Society.—*Compte Rendu*, 6 Nov. 1843.

Magneto-electro-plating, &c. — Our continental friends seem somewhat behind-hand in learning what is going on here. A correspondent, M. Dujardin, has just related a fact, which he "thinks new;" that metals may be precipitated from their solutions by magneto-electricity. He quotes his experiment, on solutions of copper, silver, and gold; and says, he thinks that "magneto-electrical machines, especially if they were less costly, might very well supply the place of the different kinds of voltaic apparatus in the arts of gilding, plating, &c.;" evidently not being aware that a patent even has been taken out in England for the very purposes to which he alludes.—Vide *Compte Rendu*, 20 Nov. 1843.

Electricity connected with Thermography.—"It has been sug-

* For a description of the battery, and some data respecting the cost of the light, vide *Elec. Mag.* No. 1. p. 16—24.

Digitized by Google

gested that electricity may be engaged in the production of these spectral figures. I have just tried an experiment which appears to show the probability of this element being involved in some way in these very complicated phenomena. I arranged four electro-positive metals, nickel, bismuth, cadmium, and silver, and two electro-negative ones, arsenic and antimony, on a copper plate, and they were allowed to rest upon it for three hours. Being removed, the plate was submitted to the vapour of mercury. The space covered by the nickel was marked by being left free of vapour; that on which the cadmium lay, was still more decidedly marked in this way; where the bismuth was placed the image was exceedingly faint, but still it was observable by a deficiency of vapour; and the silver was more decidedly outlined with vapour, but none on the spot it covered. On the contrary, the space occupied by the antimony *was covered in a most remarkable manner with vapour, presenting a perfectly white spot*, which, in all positions, distinguished it from the other parts of the plate, whilst the arsenic left no trace behind."—HUNT. *Phil Mag. Dec.* 1843.

Voltaic Reaction.—After referring to the phenomena known as the polarization of the electrodes, caused by the reaction of the electrolyzed electrolyte, Mr. Grove mentions that the idea occurred to him of adding the reacting to the initial force, which from the separable character of the former did not appear impracticable. By a nitric acid battery of 6 square inches each metal, he decomposed acid water in a voltameter, of which each electrode exposed half a square inch, and obtained ·15 cubic inches of gas in six hours. For another six hours he included in the circuit a pair of platinum plates, each exposing ·42 square inches of surface, and immersed in acid water, and obtained ·10 cubic inches of gas. A third experiment of the same duration was made with the same arrangement as the second; but the direction of the current through the interposed cell was alternated as the liberation of gas became nearly imperceptible. In this case, ·23 cubic inches of gas were obtained. "Thus we get the seeming paradox that a battery performs more work with an interposed resistance than without it.

"While the battery is decomposing water in the voltameter, it is polarizing the plates, or accumulating by its own force an antagonist force; when the wires are charged, this reacting force is united in direction with the initial force,—in fact, two voltaic pairs are constituted. The reaction being exhausted, a new polarization commences, to be added, in its turn, to the initial current; and the reason why we get the increased work in the voltameter is, that *while* the polarization is proceeding, water is decomposed in the voltameter, and although this may be somewhat less than the battery would produce without the interposed plates, still this deficiency is more than made up by the action of the double pair at each alternation of the wires."—*Phil. Mag. Dec.*, 1843.

Digitized by Google

ELECTRICAL MAGAZINE.

JULY, 1844.

XLV. *On the existence of two Opposite Currents of Attenuated Matter in the Voltaic Electromotor.* Experiment of Prof. AB. FRANCESCO ZANTEDESCHI, (communicated to the Venetian Athenæum, 8th Jan., 1844.)

(TRANSLATION.)

THE opinions of philosophers are still divided, as to the transport of ponderable matter from one pole to the other of the voltaic electromotor. There are some, as Grotthuss and Martens, who are of opinion that it is only *apparent;* there are others, on the contrary, who admit that it is *actual.* This diversity of opinion owes its origin to the great deficiency of positive proof. An experiment, which our Brugnatelli devised, at the end of the year 1800, demonstrates the actual transport of matter across the liquid, which is interposed between the poles of the voltaic apparatus. I have seen gold amalgamated, when it was immersed in water, at the distance of more than six lines from the mercury. To this experiment, made in 1816, may be added that of Porret, who observed the transport of water from the positive to the negative pole; this was analysed, in 1825, by De la Rive; and finally, there is Becquérel's experiment, on the regular movement of light bodies floating on the water, from one pole to the other. However, we must not forget that, in our own times, the secondary polarity of the connecting wire and of the liquid interposed between the poles, has been investigated; and that Dr. Hare and Prof. Silliman have observed that, between the two charcoal points, at which the voltaic spark is manifested, there is a transfer of pulverised carbon, directed from the positive to the negative pole; and that Dr. Fusinieri, from the united results of several observed phe-

Digitized by Google

nomena, shows that the force of the attenuated matter must be also the principle common to the two electricities, and that the action of the new force is concerned in the production of the electric and magnetic effects. Now, I have experimentally demonstrated this connection; I have also discovered the two opposite currents of attenuated matter from one pole to the other; and I have detected its nature, if I may use the term, by its action. In the mean time I will describe the arrangement of the apparatus, and the cautions which must be observed in these experiments, and the effects to which I would direct attention.

The apparatus that I shall adopt in these experiments, is the following, which I have described in my Treatise on Electrotype. It consists of two cylindrical vessels of very transparent glass. The external one is 13 centimètres (5 in.) high, and 9 (3½ in.) wide, and contains pure water and the zinc plate. The inner cylinder is 9 centimètres high (3½ in.), and 5 (2 in.) wide. At one end, where the membrane, which forms the bottom, is attached, it expands circularly; and its diameter is 8 centimètres (3 in.). This vessel is nearly filled with a very concentrated solution of sulphate of copper; and in it the negative plate, which is of copper, is immersed. The circuit is formed, in the usual way, by means of binding-screws. I have said that I made use of pure water; but more frequently I used that from the cisterns of Venice. Other common waters lose their transparency under the action of the battery; so that we are not able to see what is going on within the water. For the same reason I do not employ acid; or else I only introduce a single drop. The effervescence from the chemical action takes away the transparency of the liquid, and gives it such a character, that, on account of the agitation, there is no possibility of distinguishing any regularity of effect. The water in my apparatus remains apparently tranquil, and very transparent to the naked eye. Except that here and there it is occasionally traversed by a few bubbles of hydrogen. Great care must also be taken that the membrane be very perfect, and not in any way to permit the passage of the liquid which it contains. If the experiment is to be carried on in the day-time, the apparatus should be placed opposite to a window, exposed to a good light; and with a good lens, the liquid must be looked through in the direction whence the light comes. If the experiment is to be made at night, a wax taper may be used, in place of the light of the sun: experience will teach the experimentalist the mode by which he may obtain the greatest field of light and distinct vision.

Digitized by Google

Suppose now that in the external vessel there is nothing but the purest water, and in the internal nothing but solution of sulphate of copper: as soon as this vessel is introduced into the other, and the membrane is in contact with the two liquids, the sulphuric acid traversing the membrane diaphragm, enters into the water; sometimes under the appearance of films with thick sides, or with linear expansions at the edges of the films; at other times, under the aspect of filaments having a sinuous and undulatory motion, and swelling at the extremities, not unlike falling drops; and these filaments, when carefully observed, are composed of other very fine filaments, all endowed with a peculiar movement of their own. If the apparatus is left to itself, and the solution is always kept saturated by means of crystals of sulphate of copper, at the end of about three days, the solution will be found to have risen 15 millimètres ($\frac{1}{2}$ in.) above the original level; and, in the mean time, the water in the external vessel will have acquired a colour. There will be then endosmose and exdosmose, with the particular phenomena of the escape of the sulphuric acid in the form of films and filaments. Sig. Fusinieri, who saw these phenomena in my house, advised me to reverse the arrangement of the liquids. I poured into the external and inferior vessel the solution of sulphate of copper; and within it I placed some pieces of the said sulphate, so that the solution should always remain saturated. In the internal and upper vessel, I poured water from a good cistern; and as soon as the membranous diaphragm was in contact with the solution, the sulphuric acid appeared darting in the form of films or of bundles of filaments, with so much force as to arrive at the surface of the water and agitate it. Here these jets divide not unlike a fountain of water does, when it reaches its maximum height; the expansion and breaking into films and filaments causes an agitation in all directions, both horizontally and perpendicularly. This peculiarity merits all the attention of the philosopher, because it shows that the ascending jets are continued in the form of fasciculi or films with thick sides, even when they attain the horizontal level, by an intrinsic force which overcomes that of gravity, or specific weight, or the mechanical action of the superposed water which presses on them. If an effect of attraction existed, it would not be possible to obtain it in filaments, or films with thick lines at the boundaries; we should have to divide and subdivide progressively in all directions ad infinitum.

Having, by these means, obtained a clear view of the phenomenon, and having seen that it is of the class of those

Digitized by Google

that are included in Sig. Fusinieri's expansive force, I replaced the water in the outer vessel, and within it I placed the zinc plate. And in the inner vessel I replaced the solution of sulphate of copper, which is always kept saturated, by the mode I have mentioned; and in this I put the copper plate, the circuit being completed as usual. At the end of three days, the phenomenon of endosmose and exosmose is also manifested; but the rise of the solution was this time less than about four millimètres. The experiment was repeated three times with constant effect. The temperature was about 11½ R. (58 Fahr.) My apparatus was therefore a *differential endosmoscope.*

I should mention that, according as the circuit is completed, the jets of acid were more copious and quicker, and that it spreads itself in a normal direction at the bottom of the zinc itself. I have occasionally observed that the acid rushes from the membrane with such force as to agitate the water, and carry with it light bodies which lie in its course. And thus I have seen explosions, as it were, occur on the lower surface of the zinc. The latter has its lower surface covered with pitch. I have witnessed the expansion of the acid, its darting in all directions from the particles of pitch, and its rushing principally in the direction toward which the acid current tends. The mass of water is traversed with the greatest rapidity, moving obliquely to the level of the horizon; and, on the upper surface of the zinc, I have often seen that the spheres, in which the filaments of acid terminated, are struck by the return movement, as in the other experiments which Dr. Fusinieri has investigated. Thus the matter was attenuated and reduced to a state of elasticity.

On bringing the lens near to the zinc, I have seen that on its surface, it was here and there covered with bubbles of hydrogen gas, which had the appearance of brilliant dew, some of which rise, in the form of drops, through the water, and attach themselves to the surface of the membrane. But in the field of the surface of the zinc, I have seen amongst the adhering bubbles an immense number of points, consisting of a very fine matter, which appears like a white powder, and which, as it separates itself from the zinc, becomes reduced to an exceedingly fine powder. These jets and currents carry with them the light bodies with which they meet in their course. The variations of form which were manifested, when they were well illuminated by the light of a candle, were to me a most beautiful sight.

When the lens is removed to a certain distance, so as to have some parts of the membranous diaphragm on the plane

Digitized by Google

of distinct vision, an innumerable quantity of similar points are seen, consisting of very attenuated matter, resembling a white cloudy powder, which, by its progressive division, is attenuated *ad infinitum*. These jets carry with them the light bodies that occur in their course. Thus we have light bodies ascending and descending. I made a comparison between these two currents of attenuated matter; the ascending one appeared greater, and endowed with a quicker movement than the descending; they both relax their movements as the circuit is opened; and, on the other hand, accelerate it as the same is closed. On breaking the circuit, the little bodies seem to remain neutral and suspended; and on making the circuit, they seem reanimated by a new and vigorous motion.

From all this I gather, 1st,—that, in the constant battery, the phenomena of endosmose and exosmose occur, which are modified by the voltaic electromotive action; 2nd,—That the acid is carried from the negative to the positive pole in the form of films and filaments; 3rd,—That, besides the oxidation of the zinc, and the development of hydrogen gas, there exist two contrary currents of attenuated matter, which differ from each other, both in quantity and in motion. The reciprocal transport, then, of ponderable matter from one pole to the other, according to these experiments, is no longer hypothetical; but it leaves the existence of one or more imponderable fluids distinct from ponderable matter, still hypothetical and improbable.

If an opinion upon the nature of these two opposite currents of very attenuated matter be not too premature, I should say that one is original, or the source of *action*, and is that which is directed from the zinc to the copper, and the other is derived from *reaction*, and is that of *induction*; it is that directed from the copper to the zinc. It appears to me that this mode of viewing the matter accords with all the phenomena of mutual action, and that it is exceedingly fitted to explain all the chemical phenomena of the voltaic electromotor. [B.]

Inserted in Bim. 1. c. 2. (1844) of the Annals of Science of the Lombardo-Venetian Kingdom.

Digitized by Google

LXVI. *On the Laws which regulate the Electro-Chemical Decomposition of Bodies.* By M. EDMUND BECQUEREL. From "Les Comptes Rendus," 4th March, 1844, Vol. xviii. No. 10. p. 362.

(TRANSLATION.)

THE object I have in view, in the communication that I have the honour of submitting to the Academy, is to make known the laws which regulate the electro-chemical decomposition of bodies.

Mr. Faraday has laid down, as a principle, that, when an electric current is made to pass through several metallic solutions, such as those of nitrates of copper, lead, silver, &c., equivalent quantities of metal are deposited at the negative pole in each solution. But this law is only true in a certain number of cases,—when the salt is formed of one equivalent of oxide and one equivalent of acid; and it does not explain the effects which are observed in the decomposition of a very great number of combinations.

I may cite, as examples, the hyponitrites of lead, which give, at the negative pole, two and three and a-half times as much lead as the nitrate, with the same current.

I have examined the decomposing action of electricity on series of bodies well analyzed; I have also successively submitted to experiment all the metallic chlorides, the oxides, and oxygenated water, the acetates, and the hyponitrites of lead, &c.

All the results which I have obtained, have led to the following conclusions:—

When a binary or triple compound is subjected to the decomposing action of electricity, the decomposition always takes place in a definite proportion, in such a manner that, for each equivalent of electricity employed, an equivalent of the electro-negative element, or at least of the compound, which plays the part of acid in the combination, is carried to the positive pole, and the corresponding quantity of the electro-positive element, or that which acts as a base, is carried to the negative pole.

This law may be converted into a formula as follows:—

An equivalent of a compound, formed by the union of one equivalent of acid and a corresponding quantity of base, always requires an equivalent of electricity to effect its electro-chemical decomposition.

Digitized by Google

By *equivalent of electricity*, I designate the quantity of electricity necessary to decompose an equivalent of water.

These laws only relate to the direct effect of the current, and in no degree to secondary effects; for there exist certain salts, such as the acetates of lead, which are not decomposed except by the reducing action of the hydrogen derived from the decomposition of water, and which always give an equivalent of metal at the negative pole.

If an equivalent of electricity is required to decompose an equivalent of any combination whatever, we may admit that if the two elements,—the electro-positive and the electro-negative, which form the combination, are separated and recombine, they disengage exactly one equivalent of electricity. Hence, in referring to the law above laid down, we deduce the following conclusions, which are *very important in molecular chemistry*:—

1st. When one equivalent of a body, whether simple or compound, is combined with one or more equivalents of another body, if the first plays the part of an acid in a combination, the liberation of electricity which results from their chemical action is such, that there is always produced one equivalent of electricity.

2nd. If one equivalent of a body, such as oxygen, is already combined with another, which plays the part of a base, and the combination is again united with one equivalent of the first body, that is, the oxygen, in order to form a dento-salt, there is disengaged, in consequence of this secondary action, an additional equivalent of electricity. So that the quantity of electricity liberated is solely dependent on the body which plays the part of acid in the combination.

My memoir referred to inorganic bodies only, because organic compounds are, for the most part, non-conductors of electricity; and because, when they conduct, the direct effect is so much disguised by secondary effects, that it is very difficult to recognise the definite action of electricity.

The principles which I have laid down, represent very well all the results that were obtained, so far as direct effects are concerned; so that there exists a constant relation between the chemical theory of equivalents and decompositions by electricity. It would be very important to establish them, as they would serve as a starting point to the entire electro-chemical theory. [A.]

Digitized by Google

XLVII. *A new Constant Battery.* From l'Institut. Feb. 22nd, 1844.

(TRANSLATION.)

At the sitting of the Imperial Academy, on the 29th of Sept. last, from a paper which had been communicated to him by the Prince Pierre Bagration, M. M. H. Jacobi read the following note:—

The application of the voltaic battery having lately received a great development, I think it my duty to the Academy to announce an improvement, which reduces this valuable apparatus to a state of great simplicity, and by which means it can be rendered very useful for practical purposes. Everybody is aware that nothing is more easy than to obtain a galvanic current. Take a piece of zinc and one of copper, united with a wire, place them in some acid or saline water, and you will produce that remarkable current, which is rendered evident by its chemical as well as by its calorific and magnetic effects. But we know also the many difficulties which have to be surmounted, if we wish to obtain by this means effects, the action of which is sustained and constant. The obstacles arising from the decrease of the force, which begins to be manifested from the moment the current is formed, have, for nearly half a century, checked the progress of the science, and hindered those practical applications, the possibility of which was plainly foreseen. It is to Mr. Daniell that we owe the discovery of a constant battery,—an admirable discovery, and one which has given to galvanism an entirely new impulse. I shall not speak now of the numerous changes and improvements which have since been applied to these batteries; I shall only observe, that with the great advantages that belong to all these apparatus, there are also several inconveniences, of which the following are the most serious:—

The employment of two liquids separated one from the other by a porous partition, renders the manipulation of this apparatus the more inconvenient, as the number of the elements is more considerable. During the action of the battery, and still more when the action must be interrupted for some time, the effects of endosmose present themselves, and occasion the mixture of the two liquids through the diaphragm. The liquids must be constantly kept at a certain degree of concentration or dilution, which is especially difficult to obtain when nitric acid is used. The pores of the diaphragm also are in the end often filled with crystals, which hinder the circulation of the current and necessitate a change, or repeated washing of these porous bags.

Digitized by Google

All those who make a constant use of batteries would undoubtedly prefer employing elements less energetic, but larger and more numerous, if by that means it were possible to obtain a constant battery, one, the manipulation of which was more simple; or, more properly speaking, a battery which, when once constructed, should require no further manipulation.

The following are the means by which this end can be perfectly obtained:—

Take a flower-pot, or any other vessel impervious to water, which you fill with earth, saturated with a very concentrated solution of hydro-chlorate of ammonium or sal ammoniac; you then place in it, at a certain distance from each other, a plate of copper and one of zinc, and you have a voltaic pair, which in a short time becomes perfectly constant in its action, and which can be kept in this state for months, and to all appearance even for years, provided that care is taken to moisten the soil occasionally, and to renew the zinc plate when necessary, which, as we well know, begins to dissolve as soon as the circuit is closed, which, however, takes place very feebly, or in proportion to the force of the current that is produced.

Before placing the copper plate in the earth, it is well to plunge it, for some minutes, in a solution of sal-ammoniac, and then allow it to dry, until a green film is formed on its surface. This operation greatly facilitates the effect of the battery; and it even seems to me that, in this respect, brass would be perhaps preferable to copper.

The theory of this battery cannot yet be established in an exact and precise manner; but it seems that the constancy of its action is due to this,—that the hydrogen, which would be developed at the surface of the copper, is employed to reduce the double salt of that metal, which is formed by the chemical action of the sal-ammoniac on the copper; so that the constancy of its action may be considered as the expression of a kind of equilibrium between this chemical action and the galvanic reaction. The earth, it appears, only acts as a very porous diaphragm, which prevents the salt of zinc from being reduced on the surface of the copper by the action of the galvanic current; and, at the same time, it prevents the possibility of the zinc having any chemical reaction on the salt of copper. We may add that it is not altogether impossible that the earth, like every porous body, absorbs the bubbles of hydrogen, which in ordinary batteries cover the copper plate, and, as we know, cause a diminution in electro-motive force.

It is advisable not to place the two plates too near to each other, but to give some thickness to the bed of earth inter-

Digitized by Google

vening between them. In like manner the plates ought not to be too small, because the earth opposes a great resistance to the passage of the current. I have not yet found time to get an exact numerical value of the constants of these batteries, nor to enter more deeply into the details of this combination, which, it is to be hoped, will yet receive many improvements, both by the zeal of the inventor, and in consequence of its more general use.

As great efforts are being everywhere made to advance the applications of galvanism, the publication of this invention ought to be no longer delayed. This battery, as we have already mentioned, is susceptible of many applications; and its utility is principally discovered in those cases, in which very energetic effects are less an object than a constant and prolonged action, as, for example, in the reduction of metals, in chemical decompositions, &c. I do not see what inconvenience there could be in placing in a cellar or granary some hundreds of these vessels or flower-pots, which might furnish a perpetual source of electricity, to be used at pleasure. I have myself placed in my house a battery of this kind, consisting of twenty-four elements, which has been in action for about six weeks, without there having been the least occasion during all this time to make the slightest alteration. It is needless to add that the vessels ought to be very well insulated, especially when we employ a series of many elements. As there is a great resistance in the pile itself, the loss occurring from defective insulation would become more sensible than in Daniell's batteries and others.

The invention of this battery is due to the Prince Pierre Bagration, lieutenant to the horse-pioneers of the guard, and aide-de-camp to General Vitoftoff, chief of the engineers of the guard.

I think it necessary to add one more remark. Some time ago, I placed in the earth, to the level of the water, two very large plates of zinc and copper, and by this means obtained a pair with a power, which was absolutely constant, and sufficiently energetic to decompose several metallic solutions, and, among others, that which is employed in gilding by the galvanic way. But this simple means could not be applied, when we desire to produce a greater electro-motive force,—a force, which, as we all know, cannot be obtained but by the combination of several pairs in series. Although the earth is, in both cases, made use of, it is yet evident that the process which I had employed must not be confounded with Prince Bagration's pile, which is susceptible of much greater energy. [A.]

Digitized by Google

XLVIII. *Researches on the Intensity of the Light emitted by the Charcoal in Davy's Experiment.* By MM. Fureau and L. Foucault. From "Les Comptes Rendus," 22nd April, 1844. Vol. XVIII. No. 17, p. 746.

(TRANSLATION.)

WE are well aware of the facility with which the experiment of the ignition of charcoal by the pile may now be repeated, by means of the powerful instrument which M. Bunsen has recently placed in the hands of philosophers; we have, therefore, thought it possible to attempt certain experiments with a view to comparing this source of light with the other sources, which are most remarkable for their intensity. For this comparison, we have selected solar light, and the light produced by lime when placed in the flame of the oxy-hydrogen blow-pipe.

Our object not being to make a mutual comparison of the quantities of light furnished by these different sources, but merely to compare their intensities, the choice of the photometric process become difficult; we have, therefore, thought of having recourse to the chemical properties of light. This application of photographic processes, which was pointed out several years ago by M. Arago, has not again been attempted; which obliges us to explain briefly the principles on which we have rested.

From what we know in the present day of the chemical properties of light, it is certain that we must not confound generally the *chemical* intensity of radiations with their *optical* intensity; so that we can conceive two luminous pencils of such a kind that, while the one posseses an optical intensity superior to that of the other, the other, on the contrary, exceeds it in chemical intensity.

It follows from this, that a photometric process, founded on the chemical process, can be considered as giving nothing beyond the measure of the chemical intensity of sources of light. In this sense, therefore, it will be proper to interpret what we are about to say respecting the means of comparing the intensities of two luminous sources, by their effects on sensitive substances.

If a sensitive film is exposed to the influence of the image formed by a luminous object in the focus of a lens, the degree of alteration which it undergoes, depends on the time of the exposure and on the intensity of the focal image.

If in two experiments, the time and the focal intensity remain constant, the degree of alteration will be the same;

Digitized by Google

if, while the time is the same, the same degree of alteration is obtained, we may conclude that the focal intensity is the same. Now, this intensity, i, of the focal image is connected with the intensity, I, of the luminous object, with the ray, r, from the aperture of the lens and with the focal distance, d, by the relation.

$$(1) \quad i = \frac{I\, r^2}{d^2} = I \text{ tang. } {}^2a$$

2 a being the angle under which the aperture would be seen from the focus.

Consequently, if, *in a given time, the same degree of alteration is obtained* in two similar sensitive films placed in the foci of two lenses, the different angles of which are a and a', and directed toward two luminous objects, the intensities of which are I and I'; the equality $i = i'$, of the focal intensities may be deduced; or rather, from the relation

$$I \text{ tang. } {}^2a = I' \text{ tang. } {}^2a'$$

may be deduced

$$\frac{I}{I'} = \frac{\text{tang. } {}^2a'}{\text{tang. } {}^2a}$$

Now, these tangents being given by the direct measure of the apertures, and of the focal distances of the two lenses, the relation between the intensities of the two luminous sources will be obtained.

In experiments of this kind, it is sometimes difficult to arrange the apertures and focal distances so as to obtain the same degree of alteration at the same time; it were, therefore, important, to be able to arrive at the relation I : I', by obtaining the same degree of alteration in different times.

It would be sufficient for this to admit, which at the very outset seems probable, that there is an equality of chemical action when the periods are in inverse ratio to the intensity. The extent to which this principle is true, must be examined; this has been done in the following experiments:—

We directed a dark chamber toward a lighted lamp firmly fixed; then, by varying the focal intensity, by means of variable diaphragms, we obtained a series of images of the lamp on a sensitive film; the duration of the impression for each image was in inverse ratio to the focal intensity.

We found that the successive images thus obtained are equally sensible so long as the periods and the intensities vary within the limits of 1 and 10; that is to say, so long as the relations $\frac{i'}{i} = \frac{t'}{t}$ do not attain a greater value than 10. If we continue to vary the time and the intensity beyond

Digitized by Google

that limit, we soon perceive that the images are no longer equal; for the values $t'=60\,t$ and $i'=\frac{i}{60}$, the image obtained with the intensity i' and the time t' is incontestibly more feeble than that produced by the intensity i and the time t.

It is not, then, rigorously exact to say that there is equality of chemical action, when the times vary in inverse proportion to the intensities; but our experiments have shown us that, without any sensible error, we may admit this principle for limits of times, such that we have $t' < 10\,t$.

That is to say that, within these limits, if $\frac{i}{i'}=\frac{t'}{t}$, there will be an equality of chemical action.

Reciprocally, if there is equality of chemical action in times t and t', included within these limits, we may deduce the relation between the focal intensities i' and i,

$$\frac{i}{i'}=\frac{t'}{t},$$

or, from the relation, $i = \mathrm{I}\ \mathrm{tang.}^2\, a$,

(2.) $\frac{\mathrm{I}\ \mathrm{tang.}^2\, a}{\mathrm{I}'\ \mathrm{tang.}^2\, a'}=\frac{t'}{t}$; whence $\frac{\mathrm{I}}{\mathrm{I}'}=\frac{t'\ \mathrm{tang.}^2\, a'}{t\ \mathrm{tang.}^2\, a}$; which enables us to obtain the relation between the intensities of two luminous sources in the most general cases, when the times of exposure, and apertures and foci of the lenses being different, the same degree of alteration is obtained in two similar sensitive films.

As a last analysis, we have to determine, in the series of alterations that sensitive films undergo, a fixed point, which may enable us to recognize such of them as have undergone the same degree of alteration.

The sensitive film, which we have found best fitted for this determination, on account of its preparation being tolerably constant, is M. Daguerre's iodide of silver; and the fixed point that we have adopted, is the degree of alteration at which this sensitive film begins to condense the vapour of mercury; it is the point at which the photographic image begins to arise.

This film of iodide of silver, although far less susceptible than the sensitive films at present in use, presented to us serious difficulties, on account of the rapidity with which it is acted on under the influence of the intense radiations that we were desirous of studying. The reason of our having rejected the employment of sensitive papers, may be understood; for it is true that they are less susceptible, but to prepare them of a constant character is no easy matter; and,

Digitized by Google

besides this, they do not offer, in the series of their alterations, a fixed point so easily to be recognised, as that to which we have pointed in the film of iodide of silver. We should mention, however, that the latter sensitive film itself must be prepared, for comparative experiments, by means absolutely identical and by the same person; apparently insignificant differences in its mode of preparation may cause its sensibility to vary in a very notable manner.

The experiments were made in the following manner:—A dark chamber was directed towards the source of light; the luminous body thus formed its image in the focus of the lens; this image, having very small dimensions in our experiments, by slightly displacing the axis of the instrument, we might alter its position in the focal plane.

The lens was covered by a screen, and the sensitive plate was placed in the focal plane; the screen was then raised for a period carefully counted; then, having slightly displaced the axis of the instrument, the screen was again raised, for a slightly differing period; and thus five or six successive impressions were obtained, corresponding to different times.

The plate being then exposed to the vapours of mercury, a series of decreasing images appeared, corresponding to the different times of the impression; if the experiment had succeeded, the series was incomplete; the alteration of the sensitive film, during the shorter periods of time, not having been sufficient to produce the condition for acting on the vapour of mercury. The time corresponding to the first image, that is to say, the nascent image, is noted; and the aperture of the lens, and its focal distance are measured.

By operating in the same manner on other luminous sources, we obtain, by similar means, the nascent image, the aperture of the lens and the focal distance.

From these quantities we deduce, by the equation, (2) the relation I : I′. We operated, in this way,—1st. On the sun; 2nd. On charcoal ignited by the pile; 3rd. On a fragment of lime, placed in the flame of the oxy-hydrogen blow-pipe.

1st.—For the sun, we made use of a dark chamber, fitted with an achromatic lens of 1·143 m. (45 in.) focus; the aperture was limited, by means of diaphragms, varying from 1·3 to 3· mm. (·051 to ·118 in.)

2nd.—For the charcoal of the battery, and the lime of the gas blow-pipe, we made use of lenses, the principal focus of which was shorter; then, by placing the lens at a distance from the luminous source equal to double the principal focal distance, we were able to operate on an image, the dimensions of which were the same as that of the luminous body itself.

Digitized by Google

The limited extent of these luminous sources rendered such an arrangement necessary. The focal distance determined by this position of the object was ·56 m. (22 in.) in our first experiments; and, in the subsequent ones, it was increased to 1·125 m. (44¼ in.) The aperture of the lens varied between 17 and 3 mm. (·66 to ·118 in.)

In all our experiments, the time corresponding to the nascent image was comprised between 3 seconds and ⅖ sec.; the quarters and fifths of seconds were estimated.

Solar Light.—The experiments, relating to solar light, were made in the months of August and September last, and repeated in the early days of this present month of April.

It was necessary to operate in very clear weather, and at hours near to mid-day, conditions which were rarely to be obtained simultaneously.

Two series succeeded; the one on the second of April at 15 min. past 11, during weather of remarkable purity, gave us the greatest intensity; we represent it by—1000.

The experiment, when repeated the same day, at 40 min. past noon, gave the same number—1000.

The other, on the 20th of September, at 2 o'clock, under a pale blue sky, gave a more feeble intensity—751.

It will be interesting to repeat for comparison these experiments about the time of the summer solstice, as well as at variable hours of the day; this we propose doing.

Light of the battery.—For the light of the charcoal points of the battery, we made our first attempts, by placing the points in vacuo; but we were obliged to renounce this means, on account of the rapidity with which the inner surfaces of the glass globe were tarnished. The same effect was produced in an incombustible gas; it was therefore necessary to operate in the open air, and yet to avoid the rapid combustion, which the charcoal usually employed undergoes in this case. One of us, M. Foucault, accomplished this, by employing carbon obtained from the distillation of pit-coal; this carbon, on account of the slowness of its combustion, permits us to obtain, in the open air, a steady, and, what is of more importance, a durable light.

From the very commencement of our experiments, we remarked a notable difference in the distribution of the luminous surfaces on the two poles of the battery, the positive pole being much inferior in luminous surface, and intensity to the negative pole.

The former presents a circular surface of 2 or 3 millim. ($\frac{1}{10}$ in.) in diameter, endowed with a brilliancy almost uniform throughout; beyond this space the intensity rapidly de-

Digitized by Google

creases; the latter presents a much smaller surface, and, as it appeared to us, less brilliant. The luminous arc, which unites them, emits a bluish purple light, with an optical intensity evidently inferior to that of the two poles.

The positive pole was, therefore, best adapted to our experiments, and on this we operated.

The battery, as we have said, was a Bunsen's battery, the dimensions of which were such that the carbon cylinders, with an inner diameter of 5·5 centim. (2 in.), were immersed 9 cent. (3½ in.) in the acid; the nitric acid employed gave 20 degrees, and the sulphuric 15 of the areometer.

Under these conditions, we obtained the following numbers:—

46 pairs gave an intensity of . . 235
80 „ „ „ . . 238

Although the intensity does not notably vary with the number of the pairs, it greatly increases with their increase of surface, as might be anticipated.

46 single pairs gave 235
Three similar series united pole to pole, or 46 pairs with large surfaces, the battery having been at work for one hour, gave . . 385

The very rapid diminution in the action of the battery, after it has been some time charged, even when the circuit is not closed, prevented our varying these experiments as much as we could have desired.

For instance,—

80 pairs having given an intensity of . . . 238
The same 80 pairs, 3 hours afterwards, gave . . 159
46 pairs having given 235
40 pairs, in another instance, after the battery had been charged for two hours, gave . . . 136
Two similar series, pole to pole, or 40 double pairs, gave under the same circumstances . . . 238

The increase of intensity with the surface is here remarkable.

The mean of the two former numbers, 235 and 238, must be regarded as the expression of the intensity produced by a series of Bunsen's pairs of the dimensions indicated, in numbers comprised between 46 and 80, and at the first periods of their action; we should add the condition that the circuit must be completed with the very dense charcoal that we employed; for it has appeared to me that charcoal of a less density produced also a less intensity.

This intensity may be taken as unity, and then compared with the solar intensity of April 2nd, and we have the re-

Digitized by Google

lation 1 : 4·23; the greatest intensity, 385, produced by 46 pairs with a large surface, composed in the same manner, would give the relation 1 : 2·59; but the number 385 is certainly too low, for it was obtained when the battery had been in action for an hour, and when of necessity it must have become reduced. We think we shall be below the correction, by giving the ratio as 1 : 2·5.

Light produced by the mixed gases upon lime.—We have found, for the intensity of this light, a number, which represents a feebleness quite unexpected; indeed

The solar intensity for April 2nd, being . . 1000
The intensity of the light of the gas blow-pipe, was . . . . . 6·85

This number was the greatest that we could obtain, although we augmented the pressure, under which the gas escaped as much as the apparatus we were using would allow; this pressure was produced by a weight of 20 kilogrammes (44 lbs.) on a surface of 430 centimetres (169 in.)

When the pressure was reduced, or the velocity of the escape of gas was retarded by any obstacle, the intensity rapidly decreases; indeed, we substituted a narrower orifice, and the intensity, in this case, was found not to exceed 3·4.

Instead of diminishing the orifice of the blow-pipe, we reduced the weight to 8 kilogrammes; the intensity fell to 0·86.

With the same orifice and the same weight, the addition of a leaden safety-tube, which permitted our placing the gas-holder in a neighbouring room, reduced the intensity to 0·54.

Taking the maximum intensity 6·85 as unity, and comparing it with that of the solar light and the light from the battery, we have,

With the solar light, the ratio . . . 1 : 146
With 46 pairs of large surface . . 1 : 56
With 46 ordinary pairs . . . . 1 : 34·3

The photometric process on which these determinations of intensity rest, gives in reality the measure of the chemical intensities of the luminous sources, as we have said; now, the feeble intensity found for the light produced by the gas, might be explained by admitting that the chemical intensities would be very different from the optical intensities in the luminous sources which we compare; we have, therefore, been induced to try the measure of the optical intensities, by the ordinary method of simultaneous comparison.

The difficulties of reducing this to experiment have prevented our giving to this part of our work the extent which

Digitized by Google

it deserved; however, by optical comparison of the light produced by the gas with that from the charcoal points of the battery, we have obtained tolerably distinct results.

Without describing in detail the photometric arrangement which we adopted, we may mention that, by means of a lens, the images of the two luminous sources were formed, side by side, on a translucid screen, with dimensions equal to those of the luminous object; each of the luminous pencils forming these images was limited by a diaphragm; the aperture of one of these diaphragms might be varied by insensible degrees, so as to permit both images to be brought to the same intensity. This equality being obtained, the inverse relation of the surfaces of the diaphragms gave the relation between the luminous intensities.

In our experiments, the dimensions of the two luminous surfaces were sensibly the same.

The optical intensities of the light emitted by the gas blow-pipe, compared with the light produced by 46 pairs, were found, by this method, to bear the following relations:—

1 : 26·5
1 : 33·6
1 : 37·7

The chemical intensities had been found . 1 : 34·3

Although these numbers are somewhat different, we think that we may conclude that these two luminous sources possess optical and chemical intensities which are sensibly in the same ratio.

If we consider the great difference of intensity existing between these two sources of radiations, and especially the very different nature of the physical causes, which give rise to them, we are led to generalize their result, and to regard as very probable, that the luminous radiations, emanating from different sources, but which produce white light, possess optical and chemical intensities in the same ratio.

If this principle be admitted, the measures of chemical intensity, which we have given in this work, and which refer to solar light, to that of the charcoal points, and to that of the mixed gases on lime, would equally be the measures of the optical intensities of these luminous sources.* [A.]

* After having given a verbal account of this memoir, M. Arago reverted to the experiments, now old, by aid of which he had compared, through direct photometric means, the light of the sun with that of the charcoal points of battery.

Digitized by Google

XLIX. *Addition to a preceding note* concerning the application of Daguerrien Processes to Photometry.* — By MM. H. Fizeau and L. Foucault.—From Les Comptes Rendus, May 6, 1844. Vol. 28, No. 19, p. 860.

(TRANSLATION.)

We have observed in the course of this work, certain interesting facts, which we are about to relate.

1st. *Solar Images.*—The diameter of the solar image, with the focal distance that we employed, (1·413m. = 55⅝ in.) was only 13mm. (½ in.); and yet, about the end of August, we obtained very distinctly the image of a rather large spot, which was passing over the solar disc at this period. We do not doubt but that, by means of suitable optical instruments, we might thus obtain valuable drawings of certain spots remarkable for their form and extent.

Another fact constantly occurred to us, namely, a feeble decrease in the intensity of the images from the centre to the circumference; but especially near the edges. As this fact bears upon the important question of the relative intensities of the edges and of the centre of the sun, we purpose repeating our experiments on this point; indeed, we believe that this simple remark incidentally made during our researches, is not valued in proportion to the importance of the question.

2nd. *Luminous arcs of the battery.* — The purple blue light produced between the charcoal points, possesses a chemical intensity, equal to about one-third of that which the light emitted from the positive pole possesses.

The formation of the luminous arc between certain metals, presented the following results with 80 pairs:—

All the metals employed by us as poles, produced arcs of variable colours and intensities; *forged platinum* acted as the other metals; we should mention that M. De La Rive observed the contrary with this body.

Interesting peculiarities occurred when one of the poles was terminated by carbon and the other by a metal. The positive pole being silver and the negative carbon, the arc is easily formed; the silver soon melts and distils abundantly; the negative carbon may then be withdrawn further without breaking the luminous arc, which has a remarkable stability and beauty. If the poles are inverted, the same phenomenon does not occur. The arc is formed during the first moments, as before, from the positive charcoal to the negative silver; but when the silver enters into fusion, the arc breaks. In

* Vide preceding article, p. 325.

Digitized by Google

seeking to establish it again, many difficulties are experienced; when, after a time, success is attained, the part of the arc, which touches the globule of silver, is agitated with a particular noise.

Platinum and carbon present an analogous phenomenon, but in a much less marked degree.

It seems that this fact must be connected with the phenomena of transport from the + to the — pole, studied with so much care by M. De La Rive. With regard to silver, which, as we know, absorbs oxygen, when in fusion, the rupture of the arc might be attributed to the combustion of charcoal transported even into contact with the silver; the singular crepitation of which we have spoken, supports this manner of viewing it.

3rd.—The explanation which Davy gave of the nature of luminous flames, led us to attempt closing the circuit of a batttery of forty pairs, by the flame of a taper; we then observed the following facts: — a feeble current is established, but without light; and the negative pole is gradually seen to be covered with very fine carbon, which is deposited in the form of arborizations. *

With a battery of 80 pairs, the carbon is also deposited on the positive pole with the same appearances; but in less quantity than on the negative.

4th.—A peculiar phenomenon of light is presented when water is decomposed with very fine wires, and a battery of 80 pairs; the wires are heated, without becoming red, if they are of sufficient diameter; but the gases which surround them are then luminous; their liberation being accompanied by a peculiar noise. This phenomenon is most marked at the negative pole.† It is remarkable that, as long as the gases are thus luminous the intensity of the current is much diminished. Ought this fact to be connected with the phenomena of luminous arcs?—Would there, therefore, be at the negative hole an arc formed with hydrogen?

5th.—We will terminate by calling attention to a remarkable modification experienced by the carbon, when it has undergone the highest degree of temperature that is developed during the incandescence of the poles of the battery.

The very dense carbon that is obtained from the distillation of coal, and which we have employed, has physical characters that connect it with the mineral species termed *anthracite;* on examining after the experiments of incandescence, the carbon

* Mr. Gassiot investigated this action in 1839. Vide Trans. Elec. Soc., p. 172, March 19th, 1839.—[Ed. Elec. Mag.]

† Vide Mr. Mackrell's experiments, Elec. Mag., p. 277.—[Ed. Elec. Mag.]

Digitized by Google

transported to the negative poles, and the extremity of the positive pole itself, we have noticed that its physical characters are then changed.

This carbon is soft, makes marks; its surface, when rubbed, becomes of a grey lead colour. Its characters completely assimilate it to the mineral called *graphite:* this modification is very rapidly made, and is also obtained with other kinds of charcoal. It is sufficient to move the luminous arc on the surface of one of the charcoal poles, in order that this surface be instantly covered with a film of graphite.

It seems that this formation of graphite, under the influence of a very high temperature, must play an important part in the study of mineral masses, in which this variety of carbon is so frequently found.—[A.]

L. *Result of the Electrical Experiments* of MM. PALMIERI and SANTI-LINARI. Letter from M. Melloni to M. Arago. Comptes Rendus, April 22, 1844. Vol. xviii. No. 17, p. 762.

(TRANSLATION.)

WHEN I announced to you, a few months ago, the researches of MM. Linari and Palmieri, on the induced currents of the earth, and the new results which they had obtained, that is to say, the shock, and the decomposition of water, I hoped that, as they pursued their experiments, these two philosophers would sooner or later obtain the electric spark, by the action of the terrestrial globe on their pile, or *magneto-electro-telluric** battery. This hope has just been realized more speedily and more easily than could have been anticipated. Indeed MM. Linari and Palmieri have neither augmented the number nor varied the structure or dimensions of their elements, which are still composed of cylinders of hollow iron, enveloped by seven superposed spirals of copper wire, covered with silk; they have merely given these elements a very rapid rotatory motion, by means of a good system of toothed wheels constructed by our skilful mechanician M. Baudieri. The mode by which they produce the spark is the same as that of Clarke's machine, which, as you know, consists in plunging for an instant into the mercury one of the opposite points of a little metallic piece fixed on the axis of rotation; every time that the electro-magnetic force attains its maximum of

* Vide Elec. Mag. No. 2. page 80.

Digitized by Google

intensity, which happens in MM. Linari's and Palmieri's apparatus, when the elements are in the direction of the dipping needle, and one of the extremities of the wire communicates with the metal piece, while the others is in connection with the mercury. As the cylinders of iron which carry the copper spirals, form a parallel series, it is easy to conceive that their rotation must take place round an horizontal line, perpendicular to the plane of the magnetic meridian.

The electric spark obtained by MM. Linari and Palmieri is feeble, but is perfectly visible in the dark; I have myself perceived it very distinctly several times, so also have MM. de Luca, Semmola and several other persons. To remove the doubts which might arise as to a pretended disengagement of electricity or of luminous heat due to the friction of the axis or of the air, or from any other cause different from that which forms the object of the experiment, it is sufficient to turn the metal piece a quarter of a circle, so that its points may plunge into the mercury when the axis of the elements are perpendicular to the direction of the dipping needle; for then, not the least trace of light is produced, whatever velocity may be given to the rotating machine. The light then, which is observed in the normal arrangement of the apparatus, is undoubtedly due to the electro-magnetic induction of the terrestrial globe upon the cylinders of soft iron, and from their reaction on their copper envelopes. It is even superfluous to put the straight line which passes through the two points of the metal pieces, exactly in the direction perpendicular to the plane containing the axis of the elements of the battery, for the spark becomes insensible, however little it is removed from this plane; and this may be conceived, because the displacement, feeble though it be, considerably diminishes the inductive action of the earth; now, as the spark has a very low intensity, there is no reason for astonishment, if it becomes invisible when reduced to a small fraction of its primitive value.

Finally, the first step is made, and we cannot doubt but that authors will succeed in drawing much more brilliant sparks from the electro-magnetic induction of the globe, if they will first take the pains to determine *the proper tension of the current, on the dimensions of the copper wire rolled into a helix, necessary to make the spark shine forth;* and if they then increase the *quantity* of electricity in motion, by means of a sufficient number of these helices furnished with their cylinders of soft iron, and *summed* together by the union of their homologous extremities. It even appears probable, from some

Digitized by Google

of the experiments that were tried, that MM. Linari and Palmieri will obtain the spark with the helices alone, without the cylinders; it being understood that, in this case, it will be indispensable to give them a much greater diameter, especially in the direction perpendicular to the axis of rotation; the experiment will then leave nothing further to be desired.

Meanwhile the observer, who ardently cultivates the physical sciences, cannot fail to experience a lively feeling of satisfaction, in perceiving for the first time the electric light developed by the magnetic induction of the earth. The ingenious experiments of Ampère have prodigiously extended the field of analogies between electric currents, magnets, and the magnetic action of the terrestrial globe. The fact established by MM. Linari and Palmieri, while it is a consequence anticipated by the brilliant discoveries of Faraday, puts the last seal of evidence to the principle of the identity of the electro-dynamic action of magnets, and of the force which produces the constant direction of that exceedingly valuable needle which, in cloudy weather, is the sole guide to the navigator in the midst of the immense solitudes of the ocean.—[A.]

LI. *On Voltaic Induction.* By M. Elie Wartmann.—Read before the Brussels Academy, Nov. 11, 1843. From L'Institut,* January 31, 1844. No. 527, p. 41.

(TRANSLATION.)

M. Elie Wartmann (of Lausanne) communicated his first memoir on the phenomena of electric induction; in which he makes known various general results, that he states he has obtained by his experiments, until he shall shew their relation with other electric phenomena, either unpublished or already known, which will form the subject of a second memoir.

We will first describe the apparatus that has been employed in these experiments, letting the author speak for himself:—

"I constructed a large triple *helix*, by winding at once on a large wooden bobbin, three copper wires surrounded with silk, and perfectly annealed. These wires were each 23·6 m. (77½ ft.) long, and ·003 m. ($\frac{1}{10}$ in.) in diameter. They are so arranged that, in all the convolutions, the middle wire preserves its position with regard to the other two. For brevity's sake, I shall term this the *induced wire*, and apply the term

* Vide also *Brux. Bulletins*, v. 10, No. 16; and *Arch. de L'Elect.*, l. 4, No. 13.

Digitized by Google

inducing wires indifferently to its two neighbouring wires. Their diameter is such that they can never be heated by the current to which they are exposed. The bobbin is pierced by an opening intended to receive, in certain cases, a cylinder of soft iron 0·17 m. (6·69 in.) long, and 0·05 m. (2 in.) in diameter.

"A *small helix* was also formed of three copper wires of not more than 0·0008 m. (·031 in.) in diameter. Two of these are of equal length, each containing five hundred convolutions; the third, which is a little thicker, makes only seventy-five convolutions on the rectangular wooden frame, which forms the centre of the apparatus; within this frame may be introduced a parallelopiped of soft iron. This helix differs from the former, in that the wires, in their superposed layers, are always in the same direction and do not cross each other.

"The measuring instruments that were employed, are the following:—

"(*a.*) A rheometric multiplier of three thousand convolutions, to which an almost astatic system of very light needles, gives extreme sensibility: I will call it *Hydro-electric Rheometer.*

"(*b.*) A second rheometer, also very delicate, and which I will name, *Thermo-electric Rheometer,* because its wire is larger, forming only seventy-five convolutions.

"(*c.*) A Breguet's *Metallic Thermometer,* the helix of which, composed of silver, gold and platinum, presents forty-six free coils of the spiral. It is arranged so that it may be placed in a voltaic circuit. The instrument detects 0·0714° Centi.

"(*d.*) An *Astatic Needle,* the graduated circle of which is 9·102 m. (30 ft.) in diameter: wires of various dimensions may be stretched horizontally, on the plane of the magnetic meridian, and so become parallel to the axis of the needle.

"(*e.*) A small *helix for magnetization,* formed of a plated copper wire, 0·00065 m. (·025 in.) in diameter, forming ninety-four convolutions round a reed.

"The battery employed is constant, and constructed of separate elements. The zincs are solid amalgamated cylinders, 0·15 m. (6 in.) long, and 0·045 m. (1¾ in.) in diameter; they are placed in a solution of chloride of sodium, contained in a bladder. The coppers are hollow cylinders 0·06 m. (2¼ in.) in diameter, placed in a saturated solution of sulphate of copper. The energy of this apparatus is sustained for upwards of five hours, without sensible variation.

The *additional wires,* which will be referred to, were all carefully annealed; they are of the following dimensions:—

Digitized by Google

Names of the wires.	Lengths. (ft.)	Diameters. (in.)
Copper wire ..	31·201 ..	0·02834
Platinum ,, ..	1·427 ..	0·01299
Brass ,, No. 1 ..	32·021 ..	0·09055
,, ,, No. 2 ..	51·313 ..	0·00984
Iron ,, No. 1 ..	6·004 ..	0·01338
,, ,, No. 2 ..	22·123 ..	0·05905
,, ,, No. 3 ..	72·6 ..	0·00787

"In all the experiments related in this memoir, the induced currents, formed on closing the circuit, will alone be intended, unless the contrary is expressly indicated."

Let us now pass on to the experiments which we will content ourselves with pointing out, and of which we will give the general results, without entering into the numerical details.

I. *Induction of a constant wire by a variable wire.*—The circuit of the induced wire of the large helix was closed with the thermo-electric rheometer. The circuit of one of the inducing wires was also *closed* by immersing its two ends in a capsule filled with mercury. Finally, the other inducing wire was connected with a battery of two pairs, either directly, or by the intervention of the brass wire No. 2, the length of which was varied.

Repeated experiments shewed that:—*for lengths of additional wire increasing in geometrical progression, the intensities of the induced current, measured by the rheometer, diminish in arithmetical progression.*—(α)

The same experiments were repeated, on *opening* the circuit of the second inducing wire, all other circumstances remaining unchanged. Their results were the following:—

a. For lengths of additional wire, increasing in geometrical progression, the intensities of the induced current, measured by the rheometer, also diminish in arithmetical progression.—(β)

b. The intensity of the induced current, measured by the rheometer, is greater, when the circuit of the second inducing wire is closed, than when it is open.—(γ.)

c. From the existence of the laws (α) and (β), it follows that *for lengths of additional wire, increasing in geometrical progression, the differences of intensity of the induced current, measured by the rheometer, when the second inducing wire is closed, and when it is open, decrease according to an arithmetical progression.* (δ.)

Let r be the ratio of the arithmetical progression; M, the intensity of the induced currents measured by the rheometer; E, the unity of length of additional wire (first term of the geometrical progression); q, the ratio of the geometrical pro-

Digitized by Google

gression, according to which this length is increased; a, the first term of the arithmetical progression, of which x is the general term. These quantities are connected by the relation,

$$M = r\left(\frac{\log. x - \log. E}{\log. q.}\right)$$

From the preceding logarithmic laws, we may conclude that, *when a conducting wire of a current is connected with another wire, wound into a helix, its conductibility, measured by the intensity of the current, which it is capable of inducing, varies for different portions of its length, according to another law than that which it obeys, when completing the circuit of itself, as many philosophers think, admitting that there is a proportion between the inducing and the induced current.* (ϵ)

In order to verify this conjecture, the copper wire was arranged parallel to the axis of the astatic needle, situated in the plane of the magnetic meridian, and the *maximum* amplitude of the arc traversed by this needle was observed, as well as the value of its stable deviation, in the following different alternations, (the additional copper wire being united with the first inducing wire, to close the circuit of a battery of two pairs):—

a. The circuit of the second inducing wire, and that of the induced wire, being both closed;

b. These two circuits being open;

c. One being closed, the other open;

d. The circuit of the induced wire being closed by a battery of one pair, and that of the second inducting wire being open.

e. Finally, the same conditions existing as in case *d;* but the circuit of the second inducting wire being closed by mercury.

These experiments led to the following results:—

a. The state of closing or opening, simultaneously or separately, the circuits of the induced wire, and of the second inducing wire, has no influence over the intensity of the inducing current. (ζ)

b. This intensity diminishes in arithmetical progression for lengths of inducing wire, which increase in geometrical progression. (η)

c. The intensity of the inducing current is independent of the presence or absence of a voltaic current in the induced wire: it does not vary witht he closed or open state of the circuit of the second inducing wire. (θ)

II.—*Induction of a constant wire by two wires, one of which is variable.*—Setting out with the preceding facts, we might expect to find similar results for the simultaneous induction of

Digitized by Google

two inducing currents on a wire placed symmetrically between them. The subject is naturally divided into six cases, which have been examined, calling the currents induced, when the circuit is closed, *direct currents;* and those induced on its being broken, *inverse currents:*—these six cases are characterized as follows:

a. The two inducing wires are equal, and are traversed by direct currents in the same direction;

b. The two inducing wires are equal, and are traversed by direct currents in opposite directions;

c. The two inducing wires are unequal, and are traversed by direct currents in the same direction;

d. The two inducing wires are unequal, and are traversed by direct currents, in opposite directions;

e. The two inducing wires are equal, and are traversed, the one by a direct current, and the other simultaneously by an inverse current;

f. The two inducing wires are unequal, and are traversed, the one by a direct current, and the other by a simultaneous inverse current.

First case. — Various precautions are required in the arrangement of the apparatus, so as not to put into play any disturbing force. It was found that the current of six pairs, on passing along the two wires of the small helix, heated them very rapidly. On the other hand, the great conductibility of the wires of the larger helix, making either of them alone sufficient for discharging the current of even twenty pairs, the deviations of the hydro-electric rheometer connected with the induced wire, remain the same, whether the two inducing wires, or only one was employed. The arrangement which succeeded best, consists in charging two batteries of ten pairs, and passing the current of one along the first inducing wire, and that of the other along the second, the direction of the two currents being the same. We thus find that *if the two inducing currents are equal, the rheometric deviations, which measure the intensities, are double what they are with a single current; and if the currents are unequal, the deviations are the sum of the effect of each elementary current.* (1).

Second case. — The large helix was also employed, on a pile of ten pairs. The two inducing wires were united end to end, so that the direction of the current in one was opposed to the direction of the current in the other. The equality of their dimensions and conductibility ensured the equality of the current, which traversed each of them, a current which was equal to half that of the battery. Thus *the induced currents were perfectly equal;* and as their directions were

Digitized by Google

opposed, the needle of the rheometer remained entirely motionless. The result was the same, whether the circuit was broken or closed. (κ.)

It might be objected whether the indications of the rheometer are actually the measure of currents simultaneously induced. In reply to this objection Breguet's metallic thermometer was substituted for this instrument. At breaking, as well as at closing the inducing circuit, the needle of this very delicate apparatus remained motionless. This experiment, repeated a great many times, invariably gave the same result.* The thermometer was also replaced by the small helix; little needles of tempered steel, placed within it, did not receive any magnetization, at the closing or at the breaking of the inducing circuits.

Third case.—This was examined by means of the large helix and two batteries of ten pairs, and various wires. The experiment leads to the conclusions which follow:—

a. When the length of one of the inducing wires remains invariable, and that of the other is gradually increased, for lengths of additional wire, increasing in geometrical progression, the intensities of the induced currents, measured by the rheometer, diminish in arithmetical progression, the first term of which corresponds to the sum of the effects of the inducing wires when the length of additional wire is nothing, and of which the last term is equivalent to the action of the constant inducing wire, taken isolately, or to a length of additional wire, such that the lengthened circuit is an infinitely worse conductor than the invariable circuit. (λ).

b. The value of the ratio of the arithmetical progression varies with the nature and dimensions of the additional wire employed. (μ)

Fourth case.—This was studied like the second, and with the same apparatus:

a. For additional lengths of inducing wire, increasing in geometrical progression, the deviations of the rheometer, which measures the difference of intensity of two currents, simultaneously induced, decrease according to an arithmetical progression, the first term of which is zero, and the last of which is equivalent to the action of the constant inducing wire, taken isolately, or to an additional infinite length. (ν)

b. Whence it follows that, *for additional lengths which increase in geometrical progression, the differences between the*

* This experiment is interesting from the approximation which can be made of it, with the researches of Prof. Dove on induced currents, which, although equal when measured with the rheometer, may however produce very different physiological actions. (Académie du Berlin, 1839.)

Digitized by Google

effects of induction produced by the two wires simultaneously, and those which the variable wire produces isolately, diminish according to an arithmetical progression. (ξ)

c. The value of the ratio of these arithmetical progressions, varies with the nature and dimensions of the additional wire employed. (o)

d. The presence or absence of bars of soft iron in the helices, only modifies the intensity of the induction. (π)

These laws were also verified, by substituting the magnetizing helix for the rheometer. Magnetization took place as soon as an additional length modifies the conductibility of the two circuits.

They were finally confirmed by means of the metallic thermometer. The result of this experiment may be expressed as follows:—

When an induced current is the effect of two simultaneous inducing currents in opposite directions, the one constant, the other rendered variable by lengths of wire, which increase (exteriorly to the helix) in geometrical progression, its thermic effects decrease in arithmetical progression. (ρ)

It is worthy of remark that this logarithmic law is analogous to that which M. Biot discovered for the propagation of heat in a solid bar.*

Fifth case.—This was examined with the large helix, with the thermo-electric rheometer, and with one pair of Daniell's. The magnetized needle was never deviated, although the existence of induction was shown by a sort of trepidation or shock, due to the difficulty of bringing about the closing of one circuit and the opening of the other, in a manner exactly synchronous. We conclude from this experiment that *the direct induced current is equal to the inverse current.* (σ)

Sixth case.—Studied like the former, it led to the following law:—

By elongating the wire intended for producing direct induction, by the close of its circuit, by quantities increasing in geometrical progression, the current equal to the difference of the two opposed inductric actions is found to increase in intensity in arithmetrical progression. (τ)

III.—*Influence of the state of closing or opening the induced circuit on the action of the induced current on itself.*—There is a very great correlation between the inducing and the induced circuit. When the latter is opened, we know that very brilliant sparks are obtained on the mercury at the break of the inducing current, the brilliancy of which is augmented, if a

* *Biot. Traité de physique expérimentale et Mathématique*, t. iv. p. 669. Vide also Poisson, *Théorie Mathématique de la chaleur*, p. 250 (§ 823.)

Digitized by Google

hollow bundle of iron wires is placed in the helix, and much more so if the bundle is solid. These sparks, very improperly so called, are produced, M. Wartmann says, by the combustion and volatilization of the little drop of mercury which adheres to the extremity of the wire, and which is drawn out as this extremity is further removed from the liquid of the reservoir. Now, when the induced circuit is very accurately closed, these sparks diminish considerably, and even disappear altogether.* Between the two limits of the open circuit and the circuit perfectly closed, by means of very short bodies, very massive and very good conductors, there is an infinity of intermediate degrees, to which sparks of various degrees of brilliancy correspond.

This explains why the closing of the induced circuit by means of a voltaic pile diminishes the brilliancy of the sparks, without the direction or intensity of this current having the least influence; the pile evidently plays the part of an imperfect conductor.

When the inducing circuit is closed by a voltameter, in which, for example, acidulated water is electrolyzed, the quantity of gas obtained in the unity of time is independent of the presence or absence of metal bundles within the bobbin; nor does it vary when a current in either direction is passed through or is cut off from the induced wire.

IV. *Of the Influence of Atmospheric Pressure on Induction.*—M. Wartmann has also made experiments on this subject, that have only led to the confirmation of Faraday's results on this subject, which have already been published; on which account we shall say nothing of them here.

V. *Examination of the two circumstances, under which electric currents and magnets do not produce induction.*—Since Amperè and Faraday worked on electro-magnetism and magneto-electricity, no one has been engaged, as far as I am aware, says M. Wartmann, in seeking whether the presence of a magnet or an electric current *always* induces electricity in neighbouring conductors, and whether the induction takes place *in the same manner in all directions.*

In order to acquire any datum on these problems, which are at the base of every solid theory of induction, it was necessary to examine whether a rectilinear current induces electricity spherically around each molecule of the conductor, supposed to be *electrically isotrope*, (that is to say, having an equal conductibility in all directions). Faraday's experiments

* M. Abria has in like manner stated that a circuit placed in the vicinity of the inducing wire, exercises no reaction when open. Vide *Ann. de Chem. et de Phys.* t. iii. p. 10. (Sept. 1841.)

Digitized by Google

had taught us that induction takes place in a wire placed *parallel* to the inducing wire, whether the two wires were or were not wound into a helix. Mine have proved that *induction does not take place in a sensible degree, in a wire which is at right angles to the current.*

Thus a voltaic conductor does not induce currents in neighbouring conductors, except parallel to its direction. It is on account of the parallelism between the currents which envelope magnets (according to M. Amperè) and the convolutions of the exterior helix of the electro-magnet, that the approach of a magnetic body near soft iron determines induced currents in the helix, and that the passage of the current in the latter magnetizes the bar. The same fact also explains the action of the voltaic current on the magnetic needle,—the action discovered by Œrsted, and which is the foundation of electro-magnetism.

It remained to examine whether the presence of a magnet, or of a conductor traversed by a current, always induces electricity in a neighbouring conductor placed in a suitable manner? The reply to this question must be in the *negative.*

We know that if a natural or artificial magnet or an electro-dynamic helix be brought towards a soft iron electro-magnet, the latter, on acquiring electro-dynamic virtues, produces an instantaneous induced current in its helix. But, when the approach is slowly made, the current that is developed loses its intensity, and *on increasing or diminishing the distance of the soft iron from the magnet by very slow degrees, we succeed in entirely destroying all sensible induction.*

The first experiments were made with a horse-shoe magnet, able to support eight kilogrammes (17½ lbs.) It was suspended to a metal chain connected with the arbor of a wheel. An electro-magnet was firmly fixed on the table beneath the magnet, and its helix connected with the thermo-electric rheometer. On turning the handle very slowly, the magnet could be brought to 0·004 m. (·157 in.) from the electro-magnet, without any induction in the helix; but within that distance the attraction of the magnets having brought them into contact, on account of the extensibility of the chain, the needle was violently deviated.

A horse-shoe magnet of seven plates, capable of raising forty kilogrammes (87½ lbs.) was then used. The electro-magnet was nothing more than one of the anchors of the magneto-electric machine, of which the magnet formed a part. On employing the same rheometer, we succeeded in bringing the two pieces into contact, and separating them to a distance of several millimetres, *without any sensible induction*

Digitized by Google

resulting. We operated by means of a screw, that very slowly moved the train, on which the electro-magnet was solidly fixed. The needle of the rheometer deviated several times, as soon as we rapidly varied, although through a small arc, the position of the anchor parallel to the polar surfaces of the magnet, at any one of the distances at which the experiment was made.

M. Elie Wartmann arrived at the same result, on employing the voltaic current as the cause of induction. He placed in water containing $\frac{1}{10}$ sulphuric acid, a cylindrical copper ring, so that its geometric axis was vertical. This ring was connected with one of the extremities of the rheometer wire, and at the other extremity he soldered a very thin plate of amalgamated zinc, cut into the form of a very slender tongue. This plate being plunged into the axis of the ring, produced an induced current very nearly null, when the immersion was slowly made, whilst it occasioned a deviation of 40° when the immersion took place rapidly.—[A.]

LII. *Observations on Mr. Wheatstone's Memoir.* By Prof. De La Rive. Archives de l'Electricité, 25th April, 1844. No. XIII. Vol. iv. p. 143.

(TRANSLATION.)

In an article entitled—*Some Notes on the present State of the Study of Electricity in England,* which appeared in the ninth number of the Archives* (July, 1843), I expressed a desire that Mr. Wheatstone would make known the very ingenious and delicate processes that he has devised for measuring voltaic forces. Having, by the politeness of Mr. Wheatstone, seen in action the apparatus, by means of which his processes are brought into practice, and having witnessed the experiments and researches that he has made with his apparatus, I regretted that I had not the power of making them known; and I sincerely wished that the author would not delay in publishing himself the description of them. Mr. Wheatstone has done this in the interesting memoir,† on which we take the liberty of offering a few observations.

Mr. Wheatstone's processes are founded on the principles of what is called Ohm's law;—a law which consists in expressing the intensity of a current, by means of very simple formulæ, viz.—that this intensity is proportional to the electro-motive force, and inversely to the resistance of the

* Vide Elec. Mag. p. 100. † Ib. p. 201.

Digitized by Google

circuit. Now, Mr. Wheatstone judges of the relations of electro-motive forces by the relations, which must be established in the resistances, in order to render the effects of these forces—that is to say, the intensities of the currents perfectly equal. This idea has been frequently advanced; and many philosophers have, moreover, realized it, as the readers of the Archives will have had the opportunity of seeing. But it does not appear to us to have been hitherto put into practice in a more happy manner than has been done by Mr. Wheatstone. We think that the apparatus with which he has enriched this part of science, are destined to render the greatest services to the more rigid parts of the study of Electricity.

In the course of his researches, Mr. Wheatstone passes no opinion upon the contact theory, and consequently none on the chemical theory; he even gives to electro-motive force a definition, which the partizans of either theory may equally adopt; for it neither implies the adoption of one nor of the other. By *electro-motive force*, he says, *is meant the cause which in a closed circuit originates an electric current, or in an unclosed one gives rise to an electroscopic tension.* The question is to know what the cause is which determines this electro-motive force. Is it the contact of two heterogenous particles? Is it the chemical combination of one of the elements of the pile with oxygen, or with any body which has an affinity for it? Now, among Mr. Wheatstone's experiments there is one, or rather a series, which, in my opinion, is able to throw light on the solution of this question; I allude to experiments made with pairs, one element of which is amalgam, and the other a metal, such as copper or platinum.

The author finds, for example, that the amalgam of potassium forms, with sulphate of copper, and copper, a pair having an electro-motive force greater (exactly double) than the electro-motive force resulting from a pair of amalgam of zinc, with sulphate of copper and copper.* According to the contact theory, we must conclude that the contact of copper with amalgam of potassium produces an electro-motive force the double of that produced by the contact of copper and the amalgam of zinc. According to the chemical theory we must admit that the oxidation of an equivalent of potassium produces a current which is able to overcome a resistance the double of that which can be overcome by the oxidation of an equivalent of zinc; so that a pair of copper and amalgam of potassium can produce the same effect as two pairs in series

* Vide Elec. Mag., p. 206.

Digitized by Google

formed of copper and amalgam of zinc. Now, the following fact comes in support of the latter manner of viewing the subject.

Mr. W. remarks that, whatever be the proportion of zinc or potassium, of which the liquid amalgam is formed, the electromotive force of the pair, made with either of these amalgams, does not change. This cannot happen according to the contact theory; for the amalgam of zinc or potassium must be more positive as it contains a greater proportion of either of these metals. According to the chemical theory, it is the resistance of the circuit which, when the current is constant, and there is no local action, determines the quantity of oxidizable metal that combines in a given time; this quantity, therefore, will not depend on the greater or less proportion of potassium or zinc contained in the amalgam; it will be always the same, and consequently the current will not vary in intensity. It will merely cease more quickly, if there is but little potassium or zinc in the mercury; it will last longer if there is much. It happens here, as it does when a pair is made with a plate of thin zinc, instead of being made with a thick plate, all the other elements, which constitute the pair, remaining the same; the zinc is consumed more quickly, and consequently the current does not last so long in the former as in the latter case.

There would result, from this manner of explaining Mr. Wheatstone's experiment, a principle which, for my own part, I have long admitted; it is that the oxidation of an equivalent of one metal does not produce a current with an intensity equal to that produced by the oxidation of an equivalent of another metal. I have already put forth this opinion in 1835, in a letter addressed to M. Arago.* I said:—"*Whenever there is a chemical combination between two atoms, there is a development of an electric current, the intensity of which depends on the relative nature of the two atoms. Whenever there is a chemical decomposition, and consequently a separation of two atoms, there is also the production of an electric current of the same intensity as that which results from the chemical combination of the same two atoms; but this current is determined in the contrary direction. The intensity of current developed in combinations and decompositions is exactly proportionate to the degree of affinity which exists between the atoms, whose combination or separation has given rise to these currents.*" I carefully distinguished the intensity of the current from the quantity of electricity produced in a given

* Annales de Chim. et Phys. t. lxi. p. 38.

Digitized by Google

time by a certain chemical action. So that, if we admit that the oxidation of an equivalent of zinc, an equivalent of potassium, or of any other metal, produces the same total quantity of electricity, we cannot dispute that the oxidation of an equivalent of zinc, or that of an equivalent of potassium or any other metal, when it takes place with the same degree of quickness, produces currents whose effects will be very different.

A delicate question here arises, which we will confine ourselves merely to mention, inasmuch as experiment alone can resolve it. This question is to know if we have done right to take as the expression of the quantity of electricity produced, the quantity of chemical action produced by this electricity, or resulting from its production. It seems that we are here almost reasoning in a circle. Thus, how is it that the oxidation of an equivalent of zinc, an equivalent of potassium or of any other metal, does not produce, during its oxidation, the same quantity of hydrogen? It is impossible that this should not be the case; but it does not necessarily follow that the current, which produces every equivalent chemical action, is of the same force, whatever be the particular nature of this action.

In terminating these brief observations, we may mention two points which appear to us particularly interesting.

The first relates to the employment of the apparatus, which Mr. Wheatstone calls the rheo-stat, in order to obtain a current of perfectly constant force, for certain operations in the arts where this constancy is necessary. The most perfect pair can never remain long with a force completely constant; it is, therefore, an important point to avoid this inconvenience, and this is done by diminishing or increasing, by means of the rheo-stat, the resistance which the current of the pair encounters, so that this variation in the resistance exactly compensates that which the power of the pair undergoes.

The second point refers to the determination of the inverse current, which, in consequence of polarization, arises from the platinum plates of a voltameter placed in the circuit. Mr. Wheatstone discovered, by means of the rheo-stat, that, for the same voltameter, charged with the same acid solution, this current is constant, and is independent of the force of the voltaic battery in the circuit of which the voltameter is placed. This current, which arises from the secondary polarity of the electrodes of the voltameter, is, therefore, a constant quantity, which must be deducted from the expression giving the force of the current of a voltaic battery of any number of pairs; or, what comes to the same thing,

Digitized by Google

the increase of resistance arising from the interposition of this voltameter in any circuit, is always the same, and represented by the same length of wire, whatever be this circuit. This fact is one proof more to be added to those we already possess, that the current developed by the secondary polarization of the platinum plates of a voltameter, is due to the deposit determined on these plates by the voltaic current decomposing the liquid in which they are placed. This deposit is produced more or less quickly, according to the force of the current; but, when it once takes place, it gives rise to a current of equal intensity, whatever be the energy of the cause by which it was produced. [A]

LIII. *On a new Method of determining the Velocity of Projectiles.* By Prof. Henry, College of New Jersey, U. S. From Proceed. Americ. Phil. Soc. May 30th, 1843, p. 165.

The new method proposed by the author consists in applying* the instantaneous transmission of an electrical action, to determine the time of the passage of the ball between two screens, placed at a short distance from each other, in the path of the projectile. For this purpose, the observer is provided with a revolving cylinder, moved by clock-work, at the rate of at least ten times in a second, and of which the convex surface is divided into a hundred equal parts, each part, therefore, indicating in the revolution, the thousandth part of a second. Close to the surface of this cylinder, which revolves horizontally, are placed two galvanometers, one at each extremity of a diameter; the needles of these being furnished at one end with a pen, for making a dot with printer's ink on the revolving surface.

To give motion to the needles at the proper moment, each galvanometer is made to form a part of the circuit of a galvanic current, which is completed by a long copper wire passing to one of the screens, and crossing it several times, so as to form a grating through which the ball cannot pass without breaking the wire, and thus stopping the current. During the continuance of the galvanic action, the marking end of the needle is turned from the revolving cylinder a few degrees, and pressed immovably against a "steady pin," by the well known deflecting power of the electrical current;

* Mr. Wheatstone has made a similar application. Vide notices in the present Number of the Elec. Mag.

Digitized by Google

but the moment the current is stopped by the breaking up of the long conductor, in the passage of the ball through the screen, the marking end of the needle is projected against the cylinder by the action of a fine spiral spring, similar to the hair spring of a watch, coiled around the centre pin which supports the needle, and having an elastic force a little less than the deflecting power of the electrical current. The relative position of the dots thus formed gives the time of the passage of the ball through the space between the screens, and indicates the velocity at this part of the course.

The degree of deflection of the needle can be increased or diminished by turning a screw, which alters the position of the "steady pin;" and the tension of the spiral spring can also be changed by an arrangement like that of the regulator of a watch.

In order that the position of the dots on the surface of the cylinder may exactly indicate the required interval of time, it is necessary that the time occupied by each needle in starting from rest and moving across the small arc to strike against the cylinder, should be precisely equal. If this be not the case, then the difference of these times will be the error of the instrument. This must, however, be exceedingly small, since the whole range of the end of the needle need not be more than the 20th of an inch; and the precise amount of error can be readily determined by experiment.

To adjust the apparatus for use, the galvanometers must be so placed that the two dots may be impressed on the cylinder, diametrically opposite to each other when the instrument is at rest. The cylinder being then put in motion, the two circuits of long wire are placed together, so that they can be broken at the same instant by lifting a wire common to both from a cup of mercury. If, after breaking the circuit, the dots are still found in the same relative position, no farther adjustment or correction will be required; but if this is not the case, then the springs may be altered until the dots are found in their proper positions; or the difference may be noted, and this constantly applied in each actual experiment, as an index error.

To prevent the dot from the first galvanometer being confounded with that from the second, the two instruments are placed one below the other, in different horizontal planes.

In order that the pen may not describe a line on the cylinder, re-entering into itself, and thus obliterate the dot first impressed, it may be found necessary to give the cylinder a slow ascending motion, so that a spiral instead of a circle would be marked on its surface. A chronometer for measuring

Digitized by Google

minute portions of time with a motion of this kind, is described in Young's Natural Philosophy, vol. i. p. 191.

To prevent agitations of the air, the whirling apparatus with the galvanometer, may be placed in the vacuum of an air-pump; and that part of the conducting wire, which crosses the screen, may be separated at each crossing, the ends being again united by slightly twisting them together, and the conduction being preserved by proper amalgamation, so that the force necessary to break the circuit may not sensibly lessen the velocity of the ball.

[Various other methods may be devised for impressing a mark on the revolving cylinder, at the moment of the rupture of the galvanic circuit by the passage of the ball through the screen. But the following, which has suggested itself to Prof. H. since the meeting of the society, and has been communicated by him to the reporter, may be regarded as among the best. It dispenses with the galvanometer, and produces the mark by a direct electrical action.

A part of the long wire which leads to the screen, is coiled around a bundle of soft iron wire, and over this is coiled another long wire, so as to produce an intense secondary current on the principle of the common coil machine. One extremity of the secondary circuit is connected with the axis of the cylinder, and the other is made to terminate almost in contact with the revolving surface, which, in this modification of the instrument, is surrounded by a ruled or graduated paper. It is obvious that the secondary current, which is induced by the interruption of the primary circuit, will pierce or mark the paper band at the moment of the screen being broken. There is no difficulty in effecting such a current of sufficient intensity to mark the paper; since Prof. H. in some of his experiments on Induction has developed one which gave a spark between a point and a surface of nearly a fourth of an inch in length.

The terminal points of the wires from the two screens may be placed very near each other in the same horizontal plane; if then the cylinder, revolving horizontally, has, at the same time, a slow ascending motion, the relative position of the dots on the paper will give the number of whole turns and parts of a turn made by the cylinder, while the ball was passing between the two screens. In the same way, the terminal points of wires from a number of different pairs of screens may be made to impress their marks on the surface of the same cylinder, and the velocity of the ball at the different points of its path may in this way be determined by a single experiment. REPORTER.]

Digitized by Google

LIV. *Researches on the Concentration of Magnetic Force towards the Surface of Magnetized Bodies.* By Dr. De Haldat, From "Les Comptes Rendus," May 6th, 1844. Vol. xviii. No. 19, p. 843.

(TRANSLATION.)

In 1828, I published a notice on the condensation of magnetic forces on the surface of magnets,* in which I collected some of the facts that are best fitted to throw light on a question, the solution of which is likely to establish a new analogy between the properties of bodies in an electrical condition, and those which possess magnetic force; but the facts that I related having been established by but a few experiments, whose results being somewhat undecided, variable, and occasionally equivocal, have not exactly been able to resolve the question; and I thought that I ought to undertake some new researches on this subject.

In imitation of Nobili, who has examined it before me, I had in my former experiments endeavoured to recognize if, on forming assemblages of iron wires of different diameters, in which a magnetized portion was placed in the centre of a bundle formed of similar wires in a neutral state, the magnetic force would pass from the centre to the surface of the cylinder, and condense there. The results having been null, when employing steel wires, which, by their over energetic coercitative force, oppose the propagation of the magnetic force; and having appeared doubtful for unannealed iron wires, and even for those which were annealed, I substituted thin plates of sheet-iron 15 centimetres (6 in.) long, and 15 millimetres (·6 in.) wide, of which I formed bundles, wherein the plates that occupied the centre were magnetized. However, this mode, which had seemed very fitted to solve the question, having also proved inefficacious, I had recourse to hollow steel prisms, which in their interior received magnetized prisms of the same substance, that could be drawn out after they had remained the time necessary for the propagation of the magnetic force. To this process I returned; but I effected certain modifications calculated to render the communicated magnetic force more energetic, more constant, and, for these very reasons, more easily appreciable. For the quadrilateral prism, I substituted a soft iron tube, formed of a piece of a musket, 20 centimetres (8 in.) long, and 22 millimetres, (·86 in.) in outer diameter; which, being regular and well polished, both on the outside and within, admits in its interior a solid cylinder 16 millimetres

* *Memoirs de L'Académie de Nancy*, 1828.

Digitized by Google

(·62 in.) in diameter, and weighing 340 grammes (3251 grs. troy.) This tube is closed at one extremity by an iron plug hermetically adjusted; and, at the other, by a screwing plug which fills the empty space, and moderately presses the inner cylinder. The exterior cylinder is enveloped by a very thin copper tube, surrounded by a copper wire covered with silk one millimetre (·039 in.) in diameter. The wire forms the concentric layers corresponding to the two extremities, and covering two-thirds of the envelope. A copper and zinc pair, with a good-sized surface, receives at its two poles the extremities of these wires, which develope in the iron tube the magnetic force, whose intensity is measured by three different processes.

First Process.—1*st. By the weight sustained.*—In this process our apparatus, placed in a vertical direction, is fixed by means of a cap (*échoppe* Fr.) fitted to one of its extremities; a keeper of soft iron is adapted to the other, which can receive weights of which the mass required to tear it away represents the magnetic force acquired by the apparatus, from the current conveyed by the wire connecting the poles. Six experiments made at short intervals from each other, in order to obtain more equality in the action of the pile, proves that the force acquired by this apparatus, which was represented by four kilogrammes, (9 lbs. nearly), preserved the same intensity, whether the tube of iron magnetized by induction was empty, or whether it was filled with the accessory cylinder introduced into it. The difficulties which are met with in appreciating the attractive force of magnets by this process are too well known to lead us to expect a rigorous determination, both on account of the imperfection of contact between the parts of the apparatus united by magnetic contact, and on account of the manner in which the separation is brought about. However, on contrasting the results obtained by this process with those obtained by the other more accurate method that we are about to mention, they establish generally, 1st—that the mass in magnets has very little influence over their power; 2nd—that the magnetic force resides principally, if not absolutely, near the surface of magnetized bodies.

Second Process. 2nd—*By Oscillations of the Needle.*—This process consists in giving oscillations to a magnetic needle placed in its normal direction, at a constant distance from our soft iron tube, either empty or filled with its additional cylinder, whilst the apparatus is exposed to the influence of the current that causes its magnetic condition. The distance of the north pole of the needles from the south pole of

Digitized by Google

the magnet being three centimetres (1·18 in.), it constantly gave 65 to 70 double oscillations per minute, of which the mean 62½ (?) gave differences of very little value, whether the tube were magnetized when it contained its complementary cylinder, or were empty; or when it was filled with iron filings well pressed in, or if a cylinder of soft iron wire large enough to fill it, were placed in.

THIRD PROCESS.—*3rd. By Induced Currents.*—The apparatus employed in this process is composed of two parts, the first of which is our soft iron tube, either provided with or deprived of its additional cylinder, and armed with its arrangement of copper wires covered with silk; it is provided with two pieces of soft iron, which fix firmly at its extremities, by means of which contact is made with the second part of the apparatus—also composed of a soft iron cylinder 24 centimetres (9½ in.) long, and 2 centimetres (¾ in.) in diameter, and weighing 500 grammes; armed like the tube with a thin copper sheath, enveloped in copper wires covered with silk. The magnetic force is developed in the iron tube by a pair with large dimensions, and in the cylinder by the induction of this same iron tube. The cylinder of induction communicates by means of its armature, with a sine-compass, the needle of which indicates the magnetic force developed in the cylinder. The experiments made with this apparatus being susceptible of more accurate results than those previously announced, were repeated a great many times, and in two different manners: 1st,—By the violent separation of the two magnets, a case in which the sine-compass needle is deviated, at a mean 15 or 20 degrees from the normal condition: secondly, by slowly approaching the induced magnet, to the armed iron tube, or inducing magnet, and not establishing contact between the two parts of the apparatus until the poles of the two magnets are at a very small distance apart. The needle then taking a direction very near to that which it afterwards preserves, it is much more easy to appreciate its deviation from the normal point, which is the measure of the magnetic force of the soft iron tube forming the first part of the apparatus. From the union and comparison of all these experiments, it appears that the tube, which acts as the inducing magnet, whether deprived of or containing its complementary accessory cylinder, whether it be filled with a sufficient quantity of iron filings, or with bundles of wire of the same metal, constantly determined the same deviation of the compass from its normal condition.

The very feeble sensibility of the sine-compass only giving indications limited between 15 and 20 degrees from the normal condition, I felt a fear lest they should be insufficient;

Digitized by Google

wherefore, I controlled them, by consulting Schweigger's magnetometric needle, arranged with short wires for measuring thermo-electric currents. It was placed in the same manner as the compass, after, however, having diminished the power of the current by interposing a thin conducting wire of several metres in length, and employing a zinc and copper pair of small dimensions. Used with these precautions, the needle presented, at a mean, a constant deviation of 40 to 45 degrees. If we now examine the facts that have been related, we cannot but recognize the little influence exercised by mass in magnets-by-induction, and, consequently, in all others, whatever be their kind; since they only differ from each other in the constancy of the magnetic condition, permanent in one class, transitory in others; in fact, identical, according to Ampère's doctrine. I use the term *little influence*, rather than say absolutely no influence; because experiments of this kind are not susceptible of rigorous exactness. From this consequence another necessarily results, the object of which has reference to the constitution of magnets; it is that the increase of mass is useless, always considering that this principle is exact only within limits, which depend on the chemical nature of each metal, on the intimate arrangement of its constituent molecules, on the hardness of its temper, and on its form and conditions, which can only be estimated by experiments. The other consequence, which we draw from the facts announced above relative to the general theory of magnetism, and to which it seems impossible to refuse assent in recalling to mind the nullity of the influence of the additional cylinder, is that *their force resides at their surface, or nearly at their surface.* The facts by which this principle is established, furnish us at once with a remarkable analogy between the magnetic and the electrical condition; and a difference no less astonishing is that vacuum, which exercises, as we know, so great an influence over the one, is absolutely without power over the others.

These researches relative to the influence exercised by the mass of bodies over the force, which they may acquire, are too directly related to the question relating to the power communicated to iron by currents, not to have presented themselves to my mind during this work; this influence cannot assuredly have been neglected by the philosophers who, like M. Jacobi, have directed their views toward the employment of magnetism as a source of dynamic power, capable of being applied to machines; but as, in questions of such importance, facts cannot be too largely multiplied, I enquired for the relation in which the force of a magnet of given mass

Digitized by Google

and volume increases under the influence of currents of varied intensity. The apparatus employed for the solution of this question, was composed of a small iron cylinder, bent as a horse-shoe, which, when straight, was forty centimetres (15¾ in.) long, and the diameter of which was twenty millimetres (¾ in.), its weight 500 grammes; it is needless to mention that it is armed with a proper arrangement of copper wires covered with silk. The pair employed to develope the magnetism in this temporary magnet was formed of plates of copper and zinc of 400 square centimetres of surface. This cylindrical pair was divided into six equal horizontal bands that could give currents, the intensities of which might be supposed proportional to the surfaces immersed in the acid water. Suppose then this equality of action between the surfaces immersed in a liquid exciter, the volume of which is sufficient to preserve an equality of action during the experiment, on account of care taken to repair the losses, which it undergoes, and to render its density uniform by repeated agitation, the results were such as are indicated in the following table:—

Nos. of the Exps.	Extent of surface immersed.	Force employed to separate the keeper from the magnet.
1	1	5 kilog.
2	2	10
3	3	15
4	4	17 to 18
5	5	15
6	6	13 to 14

The attractive force, developed in the temporary magnet, was measured by a very exact dynanometer: the force acquired in the first four experiments increases as the extent of the surface of the pair immersed; it decreases from the fourth, although the extent of the surface immersed always increases in the same relation; which indicates that the sur-excitation of iron, instead of augmenting its magnetic force, diminishes it, on the contrary, in a very remarkable manner. This result, which appears to me worthy of a more exact examination, was verified by the oscillations of the needle, and by our cylindrical magnet already employed, and the poles of which were armed in the same manner; the liquid exciter being renewed, we obtained the following results:

Digitized by Google

Nos. of Exps.	Extent of the surface of battery employed.	Number of oscillations of the needle per minute.
1	1	90
2	2	120
3	3	150
4	4	170
5	5	160
6	6	145

Although the forces acquired by the currents, whose power increases as the numbers 1, 2, 3, 4, do not perfectly accord in these tables, it does not the less follow that the power of magnets does not increase as do the currents; and that, consequently, the developement of this force has a limit, beyond which it cannot be carried; that there is consequently a proportion to be established between the mass of iron to be magnetised, its surface, its form, and the power of the current employed to develope it; a proportion, which must be carefully established, when we wish to use magnetic force as a mechanical agent.—[A.]

LV. *A new Electrical Machine.* By Martyn Roberts, Esq., F.R.S. Ed. &c.

(*To the Editor of the Electrical Magazine.*)

Wyther, near Leeds, 25th May, 1844.

Dear Sir,—In the fourth number of the Electrical Magazine* I find a notice of Mr. John Nott's "Rheo-electric Machine," which reminds me of an Electrical Machine I contrived and constructed in 1839, and which I believe I soon afterwards described to you ;† a short description of it may perhaps interest some of the readers of your valuable periodical.

In experimenting with the common plate glass machine, I perceived that the collective points of the prime conductor did not gather the electricity from the plate, as rapidly as this was charged by the action of the rubber; and, on testing the plate, the moment after it had passed in its revolution from the prime conductor, I found it still highly charged with positive electricity: this led me to believe that it would be a great improvement if the machine were constructed in such a manner that the prime conductor should not only collect the electricity generated or thrown upon the plate by the amalgamated rubber, but that it should also take away from the

* Page 292.

† We are glad of the present opportunity of publishing an account of a contrivance, which was privately mentioned to us some years ago.—Ed. Elec. Mag.

Digitized by Google

glass some of its natural electricity, and in this manner prepare it to receive its charge of positive electricity from the rubber, with greater avidity, as well as to contain a much larger charge than it could have done were the glass merely in a natural state, or still more so than when the glass is in a partially charged positive state, as it now is, in all plate or cylinder machines on meeting the amalgamated or charging rubber.

To effect this, I removed the collecting points from the prime conductor, and replaced them by a rubber calculated to render the plate negatively electrified, and I found the plan to answer admirably; for now, the prime conductor not only wiped off the electricity given to the plate by the rubber covered with amalgam, but it also abstracted a further quantity from the glass, and thus fitted it for receiving a much larger charge, through the amalgamated rubber, from the earth, than could otherwise be obtained. An extraordinary quantity of electricity was thus produced from a plate machine of only nine inches diameter; and I was thus also enabled to turn the machine as rapidly as I pleased; for the plate always issued from the prime conductor *or collecting* rubber, in a negative condition; whereas when points only were used on the prime conductor, I found that the plate, if turned *very rapidly*, was nearly as highly charged with positive electricity, *after it had passed the collecting points*, as when it had just parted from the amalgamated rubber.

The only difficulty I met with was to procure a rubber that would render the glass plate negatively electrified. Cat-skin was used, and this was found to answer well for a short time; but if care were not taken, the amalgam from the other rubber would sometimes accumulate upon the collecting rubber, and thus neutralise its good effects. I also ascertained the curious fact, connected with the use of cat-skin, that when the hair was long and unworn, it electrified the glass negatively; but, if the hair was worn down to its stumps, it then electrified the glass positively. Of course, if a resinous plate were used in lieu of glass, there would be no difficulty in obtaining both positive and negative rubbers. Other pursuits have prevented my following up this particular experiment; but this I have fully proved, that a machine, fitted up with two rubbers, one to excite positively, the other negatively, will enable us to circulate a much larger quantity of frictional electricity than can be obtained by any other at present known manner of mounting machines.

I remain, yours truly,

MARTYN ROBERTS.

Digitized by Google

LVI.—*Preparation of Carbon Cylinders.* By Dr. James B. M'Culloch.

(*To the Editor of the Electrical Magazine.*)

Dumfries, April 29th, 1844.

Dear Sir,—With regard to the carbon, in the first place, you must go to the gas-works yourself, and pick out pieces of the size required, the greater their density and the more metallic in appearance, the better; there is a species of it in large crystals, having a very metallic appearance, which does not answer well, having too little cohesion for working: it must first be cut into square pieces as long as you can get it, and of a sufficient diameter of course; this is best done by a common saw; the *larger* the teeth of the saw the better; a common two-handled *cross-cut* saw for wood does admirably, and water must be frequently thrown on it, as it does not cut it half so fast dry. I first tried a circular plate of iron with emery, &c., on a lathe, but found it so tedious, that the labour was more than it was worth; I next tried saws for metal, with small teeth of course, and found them also very tedious and laborious:—as I found that it chipped very easily with a sharp chisel and mallet, it struck me that a saw with large teeth, which add the powers of percussion to cutting, might answer the purpose. I tried it, and found it to answer; and, as I have already stated, water adds to its efficacy. I should think that a circular saw upon a lathe would be the best way of all, as it would do it quicker and with much less labour; and I believe that a man could cut out the blocks for a hundred, or hundred and fifty tubes in a day with it: the saw requires to be frequently sharpened. Having got your blocks, they must next be cut by the same method into whatever lengths you want them; the next is the boring of them,—a cast steel drill, (an old file makes a capital one, it must have the shoulder to make it bore true), must be chucked in a turning lathe, and the carbon held in the hand with the end screw of the lathe resting against the end of it, and gradually screwed up against the drill, as it penetrates until you are at the depth required; as the drill is blunted every half inch or so that it bores, it is better to have a number of drills, ready sharpened, at hand, in order to save time; you have now your pot, but it requires to be rounded on the outside. Set it on end, *not flat*, and chip off the corners; then chuck it in wood, put it in the lathe, like any piece of wood to be turned, and turn it with the same tools which are used for iron,—an angular pointed tool is best; I

Digitized by Google

leave, you will see,* an angle at the top; bore a small hole in this angular piece with a drill, fill it full of bees'-wax, put one hot wire after another into the hole until they come out without wax upon them; then put in a few chips of fusible metal, heat the leg of your binding-screw, put it into the hole, and hold it in position until it fixes; it is now fit for use. It is very seldom that you can get a piece of sufficient size without a crack; so, that when the pot is made, scrape a piece of black sealing-wax into powder, rub the powder into the crack, and draw a hot wire over it. A tube may be made by Bunsen's method too, but the acid runs out as through a sieve; at least I have found it so; therefore, they cannot answer the purpose of a negative element and porous pot also. I have taken the liberty of sending you a specimen, which I hope you will find to answer. Speaking of carbon, I think the great desideratum in galvanism to be discovered, is a method of making carbon the positive element, or to take the place of zinc; I can conceive no discovery which would be attended with such magnificent results as this; light, heat, mechanical power, &c., &c., would all fall under the domain of electricity; the commercial and political results would be incalculable; it would revolutionize the world, its low equivalent and value compared with the metals, and its universality—but I am getting into the realms of speculation. I intend to prosecute the inquiry myself, but I have little time. I should like to know if any experiments have been tried with such an end in view, and the results.

I remain, dear Sir,

Your very obliged and obedient servant,

JAMES B. MC CULLOCH.

LVII. *Wadham's Galvanic Remontoire Clock.* By REV. F. LOCKEY, LL. B.

(*To the Editor of the Electrical Magazine.*)

May 24th, 1844.

DEAR SIR—A galvanic clock of a novel character has lately been constructed for me by Mr. Wadham, a watchmaker,

* Dr. Mc Culloch here refers to a specimen cylinder which he was good enough to forward to us. It shall be placed in the Royal Polytechnic Institution, in case G, beside the Gymnotus Electricus, where our readers may have the opportunity of seeing it. We should mention that the cylinder answers the double purpose of a negative element and a porous cell.—ED. ELEC. MAG.

Digitized by Google

and most ingenious mechanician of this city, which may probably be worthy of notice in your valuable magazine.

I am not aware that success has attended any of the various attempts hitherto made to construct a clock which should be a correct time keeper, (or at least *as* correct as any ordinary well-made dial) and have its action *wholly sustained* by the voltaic current. This is now accomplished. The "Electrical Clock" of Professor Wheatstone (an instrument peculiarly valuable to the practical astronomer), is rather a *time telegraph** than a clock, properly so called; but the new apparatus is wholly independent of any other clock:—once started, it works *per se*.

I will endeavour to describe the mode in which this is effected. The power is derived from a small Smee's battery, (negative plate about five square inches); and this is economized probably to the utmost; for, as nearly as I can judge, it is hardly in action more than one hour out of every 20 or 24. The battery, therefore, lasts a considerable time. A single charge of diluted acid suffices for fourteen days, and the plates are then so little worn, that probably the same battery will serve for many weeks. The clock has the ordinary train of wheels, and is regulated by a balance wheel and spring from which the *escapement* is detached. It beats dead seconds. The seconds' hand is concentric with the hour and minute hands and traverses the whole dial plate.

The clock is first put in motion *manually*, by moving a small lever. This at the same moment completes the galvanic circuit, and also gives tension to a coiled spring sufficient to set the train in motion. At this instant, the galvanic current begins to fulfil its office, which is to *continuate* the motion thus imparted. It is thus effected.—At the back of the clock is placed a modification of my impact, or vibrating contact breaker. On the same centre with the pallets is a short arm or lever of ivory, which allows the closing of the circuit *at the middle of the oscillation of the pallets*, but opens it in every other position. The peculiarity of this clock therefore, is, that the battery power is engaged for a minute fraction of every second, in *renovating the tension* of the before-mentioned spiral spring (occupying the place of the mainspring in an ordinary clock) which originally gave motion to the clock train.

But it not only maintains the power at first imparted, it accumulates it up to a certain point. Every time the armature is attracted by the electro-magnet, one tooth of a ratchet wheel is advanced, on the centre of which is a pinion acting

* This is actually Mr. Wheatstone's definition.—Ed. Elec. Mag.

Digitized by Google

on the circumference of a wheel to whose centre the remontoire, or renovating spring is fixed. The other end of this spiral spring *acts against* but is *not fastened* to the interior circumference of the box containing it. Security is thus provided against overwinding the spring by any excess of galvanic power. The accumulation of power is thus obtained: the number of teeth in the ratchet wheel bears such a proportion to the rest of the movement, that at every revolution it gains a trifle on the original impulse given to the machine. Two or three advantages accrue from this provision. It makes it a matter of indifference if a few contacts are missed by the vibrating contact-breaker through the accidental presence of a particle of dust: it economises the battery, because under the accumulated power of the remontoire spring the vibrations of the balance, though isochronous, are more rapid, and the time of contact is thereby shortened: but principally the advantage is, that this accumulated power renders the clock for a short period *independent of the battery itself*. It continues to go correctly for above a minute after the battery is removed, affording hereby ample time to give a fresh charge of diluted acid, or to replace it by a fresh battery. The experience of about six weeks' action has been exceedingly satisfactory, and leaves perhaps little to be desired in the structure of an electrical clock.

I am, my dear Sir,
Very truly yours,
F. Lockey.

LVIII. *Electro-metallurgy applied to the Arts.* From Messrs. Elkington's Pamphlet.

(extracts.)

"The metal held in solution and the solvent combined originally from being in different electrical states, the metal being positive and the solvent negative. When the galvanic circuit is completed, the solution becomes a part of that circuit: the electricity then passing through the solution decomposes it, the positive element—the metal, going to the negative pole, which is the article; and the negative element—the solvent—passing to the positive pole, which is the plate of metal suspended in the solution, with which it combines." P. 15.

"In proceeding to plate an article by the electro-process, great care should be taken that it is free from all grease and

Digitized by Google

oxide; for this purpose the first operation is, to boil it in a solution of caustic alkali, by which any grease is saponified; it is then scoured with sand and water, after which it is dipped into dilute acid, which removes any oxide that may be on the surface; after rincing in water, it may be placed in the solution. It is sometimes well, before placing the article in the solution, to dip it into a dilute solution of the nitrate or cyanide of mercury, and this may be found necessary when the metal to be operated upon has an affinity for the solvent of the solution used." P. 15.

Hardness of Metals Deposited.—"It is generally believed that metals deposited by electricity are necessarily *soft*, because pure, but this is not a consequent: from experiments we have frequently made, it appears that the hardness of the deposited metal varies with the intensity of the battery; a battery of three or four pairs intensity producing silver sufficiently hard to scratch ordinary sheet silver, whilst sheet silver will not scratch it. When the intensity of twelve or fourteen pairs of plates is used, the hardness is so great that burnishing with a steel tool fails in producing a polish upon it. P. 16.

Specific Gravity of Deposited Metal.—"Speaking generally, it may be said, that exhausted solutions give a specific gravity below, and strong solutions a gravity above the ordinary specific gravity of a sheet of the same metal; that an intensity arrangement, varying from two to four pairs of plates (the solution being in a proper state) produces a deposition of the specific gravity of ordinary hammered metal, and the specific gravity increases, as the intensity is augmented; so that it is quite possible to increase the density to almost any extent by the regulation of the solution and the battery arrangement." P. 16.

"The same general arrangement is to be observed for plating with silver as already described; the *quantity* of battery power, being in proportion to the surface of the articles to be plated, and the *intensity* agreeing with the density of the solution. In a few seconds after the articles are placed in the solution and connected with the battery, they are covered with silver, and are allowed to remain therein until the necessary coating is obtained, and this is effected in from four to six hours. In order correctly to ascertain that the required quantity of silver has been received, every article is weighed previously to being placed in the solution, and again after the process is completed, and the weight entered in a book against each. After the plating is finished, the articles are taken to a lathe, and brushed with brass brushes, when they

Digitized by Google

are ready for burnishing: this process consists in rubbing the surface with great force with a highly-polished steel or bloodstone tool, until it is bright as a mirror. This is a severe test for any plated article, by whatever process made, and if a most perfect cohesion did not exist, it would be at once detected in the burnishing..... Before the introduction of this art of plating with silver, the method in use was troublesome and insufficient, and presented many disadvantages, more especially in articles of high relief, or in *representations* of solid articles, because no *solid* article *could* previously be made in plated metal." P. 19, 20.

"1. The electro-plater is not limited in the use of the metal upon which he plates; and we therefore use, as the basis of all plated goods manufactured by ourselves, a hard white metal which possesses the sound, and approaches very nearly to the colour of silver.

"2. All goods made by us are soldered with what is termed in the trade, *hard silver solder*, which is not affected by any ordinary degree of heat, aud presents a joint as strong as the metal itself.

"3. The electro-plater, in producing ornamental articles, is not obliged to incur the expense of cutting iron dies for every minute portion, neither does he, sticking all these parts together and loading them with lead, form an insecure whole; but, being under no restriction, he models his pattern, and by casting and chasing in *solid* metal, produces an exact copy, which is *afterwards* plated or gilt.

"5. The junction of the plating with the metal below, by the electro-process is perfect, without the presence of any intervening substance; the forks and spoons thus made are not open to objection, and are found to answer all the purpose of silver, in sound, appearance, and wear; those of our manufacture are all tested previously to polishing, by exposure in a furnace to a red heat." P. 22, 23.

"Besides offering many and great advantages in the manufacture of plated goods, the principle of electro-deposit opens up a new and yet untrodden field in the manufacture (or more properly the growth) of articles in solid metals, whether of gold or silver. Before the great improvements made in the art of casting, great talent and ingenuity were necessary to the smith's art, to whom was entrusted the formation of articles from the plain sheet of metal to their finish, which was often of the most minute and elaborate character, and works of art yet remain to testify to the ability of the artists. In silver, particularly, the art was carried to the highest perfection, as the productions of the celebrated Benvenuto Cellini fully

Digitized by Google

testify; in fact, workmen were then artists, and many of them of the highest order.

"With the arts of casting and chasing, that of working with the hammer in silver gradually gave way, and the artist was replaced by the mechanic." P. 23, 24.

"If the original model be of metal, upon this we pour, in a melted state, a composition of caoutchouc, treacle and glue, in certain proportions; this melts at a very low temperature, not affecting the metal, and when cool is perfectly elastic, though quite solid, so that it may be taken off the most alto-relief without injury and in one piece, and may be used many times. Into this mould we pour a preparation of wax, suet, and phosphorus; when this is cool, the mould is removed from it, and we have a counterpart of the original model. The process already described for procuring the same in silver is then proceeded with.

"Instead of employing black lead as a conducting surface upon the wax, and which must, from the mode of applying it to so soft a substance, tend to blunt the surface, being also subject to imperfections in the deposition afterwards, the phosphorus, combined with the wax, produces upon its surface a thin film of silver or gold, giving a perfect metallic surface. This process is capable of extensive application to the manufacture of highly finished ornamental articles, and to the copying of works of art; by the use of a preparation of phosphorus in a liquid state, natural objects, fruit, flowers, insects, &c., may be coated with metal without injury, or by covering them with copper and burning out the original, they may be most minutely copied in solid metal." P. 24, 25.

"For all purposes of solid deposit, for electrotyping, &c., the solution of the sulphate (of copper) is found to answer best, and is the cheapest; the method of operating with it is now generally well understood. A considerable improvement, however, may be made in this solution (when used for the purpose of covering metals), by the addition of caustic, potash, or soda, which should be added by small quantities, until the precipitate formed by it is no longer re-dissolved by the solution. The ordinary sulphate of copper contains one atom of acid for one of copper; so that in decomposing by the electric current one atom of this salt, we have *one* atom of copper only deposited; but by the addition of caustic alkali, a part of the acid is taken up by the alkali, leaving *two* or *three* atoms of copper combined with the remaining acid, forming a different salt of copper. This we find superior to the ordinary sulphate, and in practice effects a saving of battery, besides the deposit being obtained in a shorter time. When the

Digitized by Google

neutralized solution above described, is employed, it is necessary now and then to add caustic alkali to maintain the proper qualities of this salt." P. 25, 26.

"The alkaline salt of copper best suited to the coating of iron, is the double salt of cyanide of potassium and copper; it is thus prepared:—take pure dry crystals of sulphate of copper, dissolve them in water, and precipitate with the ferro-cyanide of potassium, wash the precipitate and dissolve it in cyanide of potassium and water. After the iron has been properly cleaned, which is effected by allowing it to remain for a short period in dilute sulphuric acid, heated, it is placed in the cyanide solution, heated to about 120 degrees, and connected with the battery. In from two to five minutes it will be found completely coated; the iron should then be scoured with sand, and placed in the sulphate solution;—if any portion should have been imperfectly coated in the alkaline solution, it will immediately turn black in this, in which case it should be cleaned and returned to the alkaline solution for one or two minutes." P. 27, 28.

"The electro process of applying zinc to iron overcomes all difficulties and objections; the state of the iron is unchanged, *pure* zinc only is applied, and that in the simplest and cheapest manner. The best and cheapest solution of zinc is the sulphate, which may be safely used to coat articles of iron, the zinc having the greatest affinity for the solvent of the solution. One pound of dry crystallized sulphate of zinc, to one gallon of water, forms a very good solution; very little intensity of battery is necessary,—indeed, if the *quantity* be well balanced with the surface of the articles in the solution, and the electricity has not far to travel, *no* intensity is required. The electro process, therefore, offers a cheap and effectual mode of protecting iron from oxidation by coating it with pure zinc." P. 29, 30.

"*Metallic Cloth*, is another adaptation of this art, for which article we have recently obtained patents, and which is valuable from its properties of resisting the effects of the atmosphere, as well as being water and fire proof; besides being so light, that a surface of nine square feet is made to weigh only eighteen ounces. The mode of manufacturing it is as follows:—On a surface of copper, attach very evenly stout linen, cotton, or woollen cloth, and connect with the negative pole of a galvanic battery, immerse it in a solution of copper, or other metal, connecting a piece of the same metal as that in solution, with the positive pole; decomposition takes place, and in endeavouring to reach the copper plate, the metal insinuates itself into all the pores of the cloth, forming a perfect metallic sheet." P. 30.

Digitized by Google

LIX. *The Electricity of Cloud and Fog.* By ANDREW CROSSE, ESQ. From Noad's Electricity, 2nd Ed., p. 92.

"ON the approach of a thunder-cloud to the insulated atmospheric wire, the conductor attached to it, which is screwed into a table in my electrical room, gives corresponding signs of electrical action. In fair cloudy weather the atmospheric electricity is invariably positive, increasing in intensity at sunrise and sunset, and diminishing at midday and midnight, varying as the evaporation of the moisture in the air; but when the thunder-cloud (which appears to be formed by an unusually powerful evaporation, arising either from a scorching sun succeeding much wet, or vice versâ,) draws near, the pith balls suspended from the conductor open wide, with either positive or negative electricity; and when the edge of the cloud is perpendicular to the exploring wire, a slow succession of discharges takes place between the brass ball of the conductor and one of equal size, carefully connected with the nearest spot of moist ground. I usually connect a large jar with the conductor, which increases the force of, and in some degree regulates the number of the explosions; and the two balls between which the discharges pass can be easily regulated, as to their distance from each other, by a screw. After a certain number of explosions, say of negative electricity, which at first may be nine or ten in a minute, a cessation occurs of some seconds or minutes, as the case may be, when about an equal number of explosions of positive electricity takes place, of similar force to the former, *indicating the passage of two oppositely and equally electrified zones of the cloud:* then follows a second zone of negative electricity, occasioning several more discharges in a minute than from either of the first pair of zones; which rate of increase appears to vary according to the size and power of the cloud. Then occurs another cessation, followed by an equally powerful series of discharges of positive electricity indicating the passage of a second pair of zones: these, in like manner, are followed by others, fearfully increasing the rapidity of the discharges, when a *regular stream commences,* interrupted only by the change into the opposite electricities. The intensity of each new pair of zones is greater than that of the former, as may be proved by removing the two balls to a greater distance from each other. When the centre of the cloud is vertical to the wire, the greatest effect consequently takes place, during which the *windows rattle in their frames,* and the bursts of thunder without, and the noise within, every now and then accompanied

Digitized by Google

with a crash of accumulated fluid in the wire, striving to get free between the balls, produce the most awful effect, which is not a little increased by the pauses occasioned by the interchange of zones. Great caution, must of course, be observed during this interval, or the consequences would be fatal. My battery consists of fifty jars, containing seventy-three feet of surface, on *one side* only. This battery, when fully charged, will perfectly fuse into red-hot balls thirty feet of iron-wire, in one length, such wire being $\frac{1}{3}\frac{1}{7}\frac{1}{0}$ of an inch in diameter. When this battery is connected with three thousand feet of exploring wire, during a thunder-storm, it is charged fully and instantaneously, and, of course, as quickly discharged. As I am fearful of destroying my jars, I connect the two opposite coatings of the battery with brass balls, one inch in diameter, and placed at such distance from each other as to cause a discharge when the battery receives three-fourths of its charge. When the middle of a thunder-cloud is over head a crashing stream of discharges takes place between the balls, the effect of which must be witnessed to be conceived.

"As the cloud passes onwards, the opposite portions of the zone, which first affected the wire, come into play, and the effect is weakened with each successive pair till all dies away, and not enough electricity remains in the atmosphere to affect a gold-leaf electromotor. I have remarked that the air is remarkably free of electricity, at least, more so than usual, both before and after the passage of one of these clouds. Sometimes, a little previous to a storm, the gold leaves connected with the conductor will, for many hours, open and shut rapidly, as if they were panting, evidently showing a great electrical disturbance.

"It is known to electricians, that if an insulated plate, composed of a perfect or an imperfect conductor, be electrified, the electricity communicated will radiate from the centre to the circumference, *increasing* in force as the squares of the distances from the centre; whereas in a thunder-cloud the reverse takes place, as its power *diminishes* from the centre to the circumference. First a nucleus appears to be formed, say of positive electricity, embracing a large portion of the centre of the cloud, round which is a negative zone of equal power with the former: then follow the other zones in pairs, diminishing in power to the edge of the cloud. *Directly below this cloud*, according to the laws of inductive electricity, must exist, on the surface of the earth, a nucleus of positive or negative electricity, with its corresponding zone of positive, and with other zones of electrified surface, corresponding in number to those of the cloud above, although each is oppositely

Digitized by Google

electrified. A discharge of the positive nucleus above into that of the negative below, is commonly that which occurs when a flash of lightning is seen; or from the positive below to the negative above, as the case may be: and this discharge may take place, according to the laws of electricity, through any or all of the surrounding zones, *without influencing their respective electricities* otherwise than by weakening their force, by the removal of a portion of the electric fluid from the central nucleus above to that below: every successive flash from the cloud to the earth, or from the earth to the cloud, weakening the charge of the plate of air, of which the cloud and the earth form the two opposite coatings. Much might be said upon this head, of which the above is but a slight sketch."

Magnificent and astounding as a spectacle such as above so forcibly described must be, it was, if possible, exceeded in brilliancy by the electrical phenomena observed some years since by Mr. Crosse, during a dense November fog, of which he has favoured me with the following interesting account:—

"Many years since, I was sitting in my electrical room, on a dark November day, during a very dense driving fog and rain which had prevailed for many hours, sweeping over the earth, impelled by a south-west wind. The mercury in the barometer was low, and the thermometer indicated a low temperature. I had at this time 1,600 feet of wire insulated, which crossing two small valleys, brought the electric fluid into my room. There were four insulators, and each of them was streaming with wet, from the effects of the driving fog. From about eight o'clock in the morning until four in the afternoon, not the least appearance of electricity was visible at the atmospheric conductor, even by the most careful application of the condenser and multiplier; indeed, so effectually did the exploring wire conduct away the electricity which was communicated to it, that when it was connected by means of a copper wire with the prime conductor of my 18-inch cylinder in high action, and a gold-leaf electromotor placed in contact with the connecting wire, not the slightest effect was produced upon the gold leaves. Having given up the trial of further experiments upon it, I took a book, and occupied myself with reading, leaving by chance the receiving ball at upwards of an inch distance from the ball in the atmospheric conductor. About four o'clock in the afternoon, whilst I was still reading, I suddenly heard a very strong explosion between the two balls, and shortly after many more took place, until they became one interrupted stream of explosions, which died away and re-commenced with the opposite electricity in equal

Digitized by Google

violence. The stream of fire was too vivid to look at for any length of time, and the effect was most splendid, and continued without intermission, save that occasioned by the interchange of electricities, for *upwards of five hours*, and then ceased totally. During the whole day, and a great part of the succeeding night, there was no material change in the barometer, thermometer, hygrometer, or wind; nor did the driving fog and rain alter in its violence. The wind was not high, but blew steadily from the S.W. Had it not been for my exploring wire, I should not have had the least idea of such an electrical accumulation in the atmosphere: the least contact with the conductor would have *occasioned instant death*, the stream of fluid far exceeding anything I ever witnessed, excepting during a thunder storm. *Had the insulators been dry, what would have been the effect?* In every acre of fog there was enough of accumulated electricity to have destroyed every animal within that acre. How can this be accounted for? How much have we to learn before we can boast of understanding this intricate science?"

LX. *On Terrestrial Magnetism.* By Mr. John Nott, Abridged from "The Literary Gazette," Oct. 7, 14, 21, and 28, 1843.

After laying down the views already noticed in *The Electrical Magazine*, page 132,* and describing the rheo-electric machine,† he adopts the following arguments to explain why the two electricities, which he supposes to flow in different directions along the conjunctive wire, (*r n*, fig. p. 292, *Elec. Mag.*) do not coalesce and destroy each other.

"My first endeavour was, if possible, to determine the resultant directions of radiation of an electric current. For this purpose I perforated a piece of card, and passed a vertical rheophore through it, and sifted iron filings upon the card, which arranged themselves in concentric circles round the wire; proving that, in this case, the radiation was from the centre. I now placed the rheophore horizontally, and the filings arranged themselves as far as I could determine in cycloidal curves, which I conceived to be presumptive evidence of the truth of my hypothesis."

He then alludes to the magnetisation of the brass work of the system, which effect does not occur with copper. He says:—

* Vide No. 2. † Vide Elec. Mag., No. 2, p. 133, and No. 4, p. 292.

Digitized by Google

"I found, as soon as the current was established, that a statical effect was at first produced upon the needle, one pole of which was then forcibly drawn down into contact with the wire; a rapid and irregular series of oscillations then took place, the needle dipping each time as it crossed the wire; clearly proving that the needle, in this case, was under the influence of two antagonist forces; one, that of the current passing along the wire, tending to deflect it; the other, that of the magnetism developed in the brass wire, by means of this current, attracting it."

He explains this phenomenon by a spiral motion of the current:—

"Now, if we pass an electric current longitudinally over a piece of iron, or steel, it does not become magnetic; but if we cause the current to pass in a transverse direction, the iron or steel will be found magnetic. From this fact, I would deduce this consequence, that an electric current, at least that of the rheo-electric machine, passes in a spiral direction along the conjunctive wire; otherwise, it is difficult to account for its becoming magnetic."

After alluding to the peculiar colour of the electricity, as mentioned elsewhere, (*Elec. Mag.*, p. 134,) he says that the resinous electricity "seems to pass invariably from the points of the conductor to the plate, in the form of a conical flame, with the base of the cone resting on the plate, and the apex upon the point of the conductor." The peculiar radiation of electricity from magnetised bodies, which induced him to proceed in his inquiries, is thus described.

"I suspended a cylindrical magnet by a fibre of silk, and charged it highly; being in the dark, I unintentionally approached my body within a short distance of the instrument, when it wheeled towards me, and a discharge took place, which struck me as being very remarkable; for, instead of the ordinary electric discharge, the electricity flashed from the extremity of the magnet, in diverging radii, at an angle of about 45° with its axis. It was, then, highly probable that the magnetism of the cylinder was a determining cause of the peculiarity of this discharge."

This led to the magnetised globe, and the auroral experiments;* as also to the following:—

"My next endeavour was to ascertain whether, with a non-magnetic body, the same effects would be produced. I then placed a wooden globe of the same diameter in exactly the same circumstances, when no discharge from the pole could be produced; on the contrary, the electricity streamed out in all directions from the equator of the wooden globe towards the interior of the ring; but when I coated the surface of the wooden globe with metal, the discharge took place from the pole. The inference from this ex-

* Vide Elec. Mag. p. 134.

Digitized by Google

periment would be that either a metallic surface is necessary to the production of the effect, or a body of diminishing density."

The author then proceeds:—

"*Magnetism.*—Having constructed a globular magnet—the first I believe that has ever been formed—I was enabled to investigate several most interesting questions, all bearing upon terrestrial magnetism. These questions were: the resultant directions of radiation of a globular magnet, the ratio of the increase of intensity from the equator to the poles—the existence or non-existence of what are called magnetic poles—the cause of the different action of an electro-dynamic helix and of a magnet—the cause of the declination of the magnetic needle, and of the anomalies of declination upon the same parallel of latitude—the action of one globular magnet upon another. I shall now discuss these questions *seriatim*.

"The way in which I proceeded to ascertain the resultant directions of radiation of the spherical magnet was the following:—I formed it into an artificial globe, and first placed it with its magnetic axis vertical, so as to form a parallel sphere; I then sifted iron filings upon the horizontal plane that surrounded its equator. The filings arranged themselves in radii, diverging from the centre of the globe. The same effect was produced when the filings were sifted in the planes of the parallels of latitude. I then rendered its axis horizontal, so as to form a right sphere, and sifted iron filings upon the horizontal plane as before: the filings now assumed, north and south of the equator, a symmetrical and truly beautiful arrangement passing from each degree of latitude of the globe in curvilinear directions towards the plane of the equator. A simple inspection of the curves formed by the iron filings convinced me that they spring from the centre of the sphere.

"It became, then, very interesting to ascertain the nature of these curves. For this purpose I traced with a pencil upon the artificial horizon the exact forms these curves exhibited; I next transferred them to paper and continued their directions within the area of a circle equal in diameter to that of the globe. I then found that the diameter of the circle representing the axis of the globe was tangent to every one of these curves, and that no other geometrical means of drawing them was possible than that which I shall now describe.

"If, with a radius equal to half the diameter of the globe, we describe a circle and within it two diameters, at right angles to each other, one will represent the axis of the globe, and the other will be a projection of the plane of the equator. From the extremity of the latter diameter, and with the same radius, another circle must be described, to which the axis will be tangent; within this latter circle, a series of ellipses must be drawn one within the other—the eccentricity of which must increase in geometrical progression, until finally they end in a line, and to each of which

Digitized by Google

the axis will be tangent. Outside this circle a series of eccentric circles, to each of which the axis will also be tangent, must be drawn; the eccentricity of these circles must increase in numerical progression, until finally the axis, or right line, forms portion of the ultimate circle. If now, the plane thus described, be conceived to revolve upon the axis, a figure will be generated that will accurately represent the resultant directions of radiation of an artificial globular magnet, and, by analogy, of terrestrial magnetism. It is obvious, if it be allowable to reason thus inductively of terrestrial magnetism, that such a system of radiation, whether mediate, or immediate, must embrace infinity; since the axis of the earth would form portion of the ultimate circle of radiation. As, then, magnetism radiates its influence from the centre of a globular magnet, it follows that the existence of what are called magnetic poles is completely disproved; and I shall subsequently be able to show that the existence of poles or points of intensity in an elongated magnet is a mere accidental circumstance of form."

He then alludes to the electro-dynamic theory of artificial magnets, which recognizes currents circulating in solenoids parallel to the axis of a magnet; but which fails in practice, for

"In a cylindrical magnet, the points of intensity are found at a certain distance from the extremities; but in an electro-dynamic helix the maximum of intensity is found at the very extremities of the helix. This has been considered an insuperable objection to the truth of the electro-dynamic theory: but a little reflection will show that this objection has no real foundation in fact. In the first place, a hollow cylinder does not represent the surface of a solid cylinder; next, every artificial magnet has three neutral points, one in the middle of the axis, resulting from coincidence of direction of its electrical currents; and one at each extremity of the axis, resulting from opposition in this direction; therefore, the maximum of intensity will be found at the points of the magnet where these neutralising effects become equipollent."

He hence shows that magnetic intensity increases in geometrical progression from the middle of the axis of a magnet to a certain point, whence it decreases in numerical progression; and that for a magnet to be simple, its length must bear a certain proportion to its diameter; for the smaller its diameter the further will the point of intensity be from its extremity; "a convincing proof," he says, "that the magnetic force emanates from the centre of figure, and hence what are called magnetic poles must be a mere circumstance of geometrical form." After again alluding to the electro-dynamic helix, and its peculiar property, he describes an electro-dynamic sphere which he constructed as a spherica helix, with all the spirals contiguous, and which he found by

Digitized by Google

experiment perfectly to represent the surface of a globular magnet. In order to examine the internal action of such a sphere, and find "whether its internal radiation was toward the centre, and whether the resultant directions of this internal radiation were the same as those formed, by completing the curves already given," he constructed a sphere in two hemispheres, so that the interior might be accessible, with which the following experiments were made:—

"The interior diameter of this latter electro-dynamic sphere being 0·076 m., I placed a delicately suspended magnetic needle, 0·012 m. long, exactly in the centre; when the current was established, the needle was thrown into the most violent oscillations, which continued as long as the current was permitted to act upon it. When the current was reversed, the needle was reversed, but the oscillations were the same. These oscillations, I submit, establish beyond doubt that the internal radiation of the magnetic force of a globular helix is towards the centre of the figure; for when the needle was withdrawn, its magnetism was almost totally destroyed, and it had scarcely any directive power. As no such effects as those I have described take place when a needle is placed within a cylindrical helix, it follows that the action of a cylindrical helix is very different from that of a spherical one; and by analogy, the magnetism of a body, the surface of which is unequally distant from its centre, must be very different from that of a body the surface of which is every where equi-distant from its centre; and I shall subsequently be able to establish that a normal distribution of the magnetic force only exists in a globular body.

"I next sifted iron filings upon a disc of card, and placed it within the electro-dynamic sphere, so that it formed the plane of a meridian line. Having established the current, I gently tapped the table in order that the filings should be free to obey the action of the current. I then observed the filings aggregated into a concentric circle within the sphere, and this circle formed by the iron filings was marked into striæ parallel to the axis. Now this simple experiment, coupled with these facts: first, that the external radiation of the magnetic force of an electro-dynamic sphere is identical with that of a globular magnet; next, that the internal radiation of the same force is directed towards the centre of the figure, indirectly proves that the graphical representation which I have given of magnetic radiation is correct, and thus pushes the electro-dynamic theory perhaps to its utmost experimental generality, and renders it very difficult to doubt of its truth."

In order now to ascertain the law of the increase of intensity from the equator to the poles, he operated thus:—

"To effect this object, I suspended a magnetic needle, 0·015 m. long and 0·0035 m. in diameter, by a fibre of a *cocoon*, and rendered it astatic by means of a powerful magnet. I then placed the magnetic globe, with its axis lying in a horizontal plane, at a

Digitized by Google

distance of 0·040 m. from the needle. During these experiments I found, no matter how small the oscillations of the magnetic needle, that they are far from being isochronous. I therefore, in order that the elongation should be alike in each instance, permitted the needle to assume a position of equilibrium, opposite each degree of latitude of the globe, the intensity of which I wished to ascertain. I then deflected the needle from this position to a right angle, and counted with a stop-watch the number of seconds during which 25 oscillations were performed at every 10° of latitude of the globe. The results gave an intensity increasing in numerical progression from the equator to about 75 deg. of latitude; from which point it decreases in the same proportion to the pole. This decrease, from the latitude of maximum intensity to the pole is a fact highly confirmatory of the truth of the electrodynamic theory; for if such were not the case that theory would be doubtful. The total intensity being inversely as the squares of these numbers, if the results thus found be compared with the mean results deduced from intensity observations at corresponding points of the earth's surface, the ratio of the increase in both cases will be found to approximate very closely.

"Having thus indirectly established the fact that the magnetic force of a globular magnet is radiated in curvilinear directions from its geometrical centre; or, in other words, that its magnetic poles are coincident with its centre of gravity; it follows, if this be true, that its action upon a freely suspended magnetic needle, at any point, would be identical with that deduced for the same point from Biot's beautiful law, tan. inclin.=2 tan. lat. To prove this, I first observed the inclination for Cork, and found it to be 70° 51′. I then calculated it, assuming as one of the elements not the magnetic, but the geographic, latitude. The result was, by a small quantity, less than that found by observation. I then changed the formula to the following equation: 2 tan. lat. 3, intensity = inclination; and I found the result by calculation equal to that given by observation. I therefore, adopted this latter formula as correct, and calculated by means of it the inclinations for every 10° of latitude—assuming the intensity as given by the magnetic globe."

On bringing these calculations to experimental test at the corresponding parallels of the magnetic globe, the results precisely coincided. In illustration that nought else but a globe gives the normal form of magnetism, he has the following experiment:—

"I took a piece of steel-wire, equal in length to the diameter of the magnetic globe; and placed at each side, and parallel to it, a number of pieces of the same wire, of diminishing lengths, so as to form, when united, a complete circle, and thus represent a meridian section of the globe. I magnetised these wires separately, and observed the distribution of the magnetic force in each piece.

Digitized by Google

I then placed them upon a waxed card, so as to form a circle, and sifted iron filings upon them. The distribution of the filings was now completely altered by the juxtaposition of these magnetic solenoids, and was perfectly identical with that which took place when iron filings were sifted round a meridian plane of the globe itself. This experiment is conclusive as to the non-existence of magnetic poles, and proves that the great intensity existing near the extremities of elongated magnets is merely an accidental circumstance of form. If we suppose this circle of wires to revolve upon its diameter, a magnetic sphere would be generated, the surface of which would consist of magnetic poles, in the ordinary sense of the term."

He then goes on to complete the analogy between the magnetic globe and the electro-dynamic sphere.

"I shall now direct attention to the action of an electro-dynamic globe of nine inches diameter upon the magnetic needle. In constructing this globe, I gave it a motion in latitude elevated or depressed, but no motion in longitude; as, different from the globe of Mr. Barlow's construction, I made the magnetic pole coincide with the extremity of the axis of the globe itself. I then placed over the equator of this instrument a dipping-needle, rendered astatic by a powerful magnet; so that the plane of motion of the needle was coincident with that of the axis of the globe. When the globe was magnetised by the passage of an electric current the needle became horizontal. I then gradually elevated the north pole of the globe, so as to change the latitude of the needle, and noted the amplitude of inclination for every ten degrees of latitude. The results in this case were the same as those previously given by the artificial magnetic globe, and the needle always assumed a vertical position before it reached the pole at about seventy-five degrees of latitude,—a fact which proves that the parallel of maximum intensity exists at about seventy-five degrees of latitude, as I have also shown to be the case with respect to the globular magnet.

"I next placed the electro-dynamic globe with its axis in the magnetic meridian, and rendered the needle astatic by position, that is, with the plane of its motion at right angles to the plane of the meridian, and inclined to the horizon at an angle equal to the compliment of the inclination. The equator of the globe being brought under the middle of the needle, the latter placed itself in the meridian plane of the globe, or relatively due north and south. The pole of the globe was then gradually raised, so as to change the latitude of the needle, which at first slowly moved west, then rapidly until the needle reached seventy-five degrees of latitude, where the declination amounted to ninety degrees, or the needle pointed relatively east and west, showing that at this parallel of latitude the action of the globe was equal upon both extremities of the needle. From this point the declination increased, until the needle arrived at the pole, where the declination amounted to 180°,

Digitized by Google

or the needle was reversed. At the opposite hemisphere the declinations were symmetrical, but in opposite directions. With the globular magnet, and a needle rendered astatic by position, analogous declinations also take place. We have then these facts established: that in an electro-dynamic sphere, as well as in a globular magnet, the ratio of the increase of intensity from the equator to the poles is the same; that the distribution of the magnetic force is the same in both bodies; that their action upon the inclinatory, as well as upon the declinatory needle, is the same; and consequently the identity of the force existing within, or emanating from these bodies, is fully demonstrated; for, though it is possible that similar effects may be produced by different causes, yet where these effects are numerous and identical, we may with moral certainty deduce an identity of course."

Terrestrial Magnetism. — The author now shows the different results of the composition of the forces produced by the currents of an electro-dynamic solenoid, and those of a sphere; and that the more convex the surface of a magnet is, the less will be the diminution of intensity at the equatorial regions; and the more concave, the greater the diminution. To follow out his analysis he continues:—

"I magnetised the interior of a steel tube, and floated it upon mercury; a small cylindrical magnet was then held in a line with the axis of the tube, and with its north pole towards the south pole of the tube; the tube was then attracted, and the motion thus communicated continued until the tube enveloped the magnet; the north as well as the south poles of each were then adjacent. The action of a steel tube, when magnetised internally, is therefore analogous to that of an electro-dynamic cylinder.

"Again: if the tube, instead of being magnetised internally, be magnetised externally, and a small magnet be now introduced within it, so that the homonymous poles be adjacent, the tube will be repelled, and pass from over the magnet. Hence, when one magnet is lifted up by another, their axes, instead of being in a line, form an obtuse angle; because the forces of the north pole of one magnet do not coincide in direction with those of the south pole of another; a perfect coincidence could only arrive when the homonymous poles of both magnets would also be coincident. So that we may conclude that the north pole of one magnet attracts the south pole of another only as a consequence of the attraction in a particular direction of the mass of one magnet for the mass of the other."

He next proceeds to generalise these facts, in order to unfold the theory of terrestrial magnetism. He gives the phenomena of the direction and the dip of the needle; and its verticality at certain spots of the globe; he considers the position as indicating, not a magnetic pole, but a meridian of

Digitized by Google

maximum intensity, and "that the points of intersection of magnetic meridians, as determined at the equator, are the true magnetic poles of the earth; or, in other words, are the centres of the planes of the parallels of latitude of maximum intensity. As, at the equator, in every meridian, the magnetic needle may be said to point north and south, it follows that the magnetic poles are coincident with the poles of the earth." The following paragraphs are to show that the magnetism is diffused over the surface, and is not within the earth. Our readers, who are curious for the arguments, may consult the valuable journal from which we make our abstract.

Universal Magnetism.—The author here traces the connection between gravity and magnetism, in illustration of which we make the following extracts:—

"Having a globular magnet of 0·076 m. in diameter, I procured another 0·020 m. in diameter, and floated the latter upon mercury, with its magnetic axis horizontal. I then held the large globe, with its magnetic axis also horizontal, at a certain distance from the surface of the mercury: the small globe was attracted and drawn beneath the equator of the large one; the magnetic axes were then parallel, and a vertical line would pass through the centres of both bodies. I then gradually lowered the large globe, and when it came within a short distance of the small one, the latter rolled off in the direction of the plane of its equator, so that the axes still remained parallel, but the line passing through the centres of both bodies, or what may be called the radius vector, was inclined to the horizon. This was repeated several times, and the same effect followed. Now this fact incontrovertibly establishes the existence within these bodies, not only of a principle of what may be called self-defence, but also one of a revolutive nature; so that if these bodies were free to move, they would not only rotate, but revolve round one another. It is therefore evident that magnetism would account for the rotation and revolution of the bodies of the solar system. The large globe being raised up to its original position, the small one again placed itself directly beneath the centre of the large one, as I have previously described. I then inclined the axis of the large globe about 23 deg. below the horizon. The small globe now moved off in the vertical plane of its axis, and towards that point of the horizon to which the inclined pole of the large globe was directed, and took up a definite position at a much greater distance from the large globe than when the axes of both bodies were parallel. The line passing through the centres, or the radius vector, now formed an obtuse angle within the axis of the small globe, and the plane formed by the meeting of these lines was vertical. If the small globe be now conceived to revolve round the large one, in a plane passing through the radius vector at right angles to the plane formed by the meeting of the radius vector and the axis, it is quite evident that attraction would gradually increase,

Digitized by Google

until the small globe reached that point of its orbit where the radius vector would form a right angle with its axis; for then the axes of both bodies would be lying in parallel planes, and their attracting poles would be opposite and equi-distant, and therefore the extremity of the radius vector would describe an ellipsis; and the greater ellipticity of the orbit would depend on the greater or less obliquity of the axis of rotation to the plane of revolution. It follows that magnetism would also account for the ellipticity of the earth's orbit."

By somewhat similar principles, he explains the non-rotation and revolution of satellites, the eccentricity of their orbits, the rotation of the lunar orbit, &c., and concludes with a belief that universal gravitation will be found to be universal magnetism.

SCIENTIFIC MEETINGS.

ROYAL SOCIETY.

A description of an extensive series of the Water Battery, with an Account of some Experiments made in order to test the relation of Electrical and Chemical action, which takes place before and after completion of the Voltaic Circuit.—By J. P. Gassiot, Esq., F.R.S. &c.—Read Jan. 26, 1844.

In a former paper printed in the Phil. Trans. 1839, the author described experiments made with powerful voltaic batteries, with a view of determining the possibility of obtaining a spark before completion of circuit. This, which he advisedly called an *anticipated* effect, did not occur. Soon after this Mr. Crosse obtained the spark from a series of 1626 cells of zinc and copper excited with river water. The author, pursuing his researches, constructed a series of 3520 pairs of zinc and copper, each in a separate glass vessel, well covered with lac-varnish and insulated by being on slips of glass covered with lac. The cells were placed on 44 oaken boards, also covered with lac-varnish, each board containing 80 cells, and sliding into a wooden frame, where they are further insulated by resting on pieces of thick plate glass, similarly varnished.

In describing the effects produced by this apparatus the author draws a distinction between the static and the dynamic effects, and treats of each separately. The conclusions to which he arrives are the following:—

1. The elements constituting the voltaic battery, assumed polar tension before the circuit is completed; and this even with a single cell; the polar state is shown to exist by the action on the electro-

Digitized by Google

scope of the respective terminals of the series; the kind of electric tension being the converse at either end.

2. When the tension thus produced is exalted by a succession of series a succession of sparks pass between the polar extremities of the battery before their actual contact.

3. The static effects preceded and are independent of the completion of the voltaic circuit, as well as of any perceptible developement of chemical or dynamic action.

4. When the current is established, whether by actual contact of the extremities, or merely by their approximation, so as to admit of a succession of sparks, the dynamic effects on the galvanometer are the same; in the latter case each spark produces a true and proper deflection of the needle. It is hence inferred that the current, even when the circuit is closed, may be regarded as a series of discharges of electricity of tension succeeding each other with infinite rapidity.

5. In a battery the chemical elements of which have but a feeble affinity, as in the water battery, the tension rises very slowly.

6. In order to produce static effects in a voltaic battery, it is an indispensable requisite that the elements be such as are capable of combining by their chemical affinities, and the higher those affinities are exalted, the smaller is the number of pairs in series required to exhibit the effects of tension. The static effects, elicited from a voltaic series, afford, therefore, direct evidence of the first step toward chemical combination, or dynamic action.

The author concludes by observing that the chemical effects obtained in most of the experiments described are very feeble; but are precisely of the same character as those exhibited by more powerful voltaic combinations; and he thinks it may fairly be concluded that the rationale of each is the same, and that they differ only in the amount of action.

April 18.—Mr. Gassiot communicated some further experiments on the subject of the above memoir, and described an instrument, by means of which he had been able to obtain very readily and without even the aid of a Zamboni's pile, the effects of tension from a single cell of Grove's Nitric Acid Battery. The instrument is a bell glass, protecting two parallel gilded discs, which are to be connected with the terminals of the cell; from the cap of the electroscope is suspended a single gold leaf between the discs; this is electrized by the induction of a rod of glass or resin; and the gold leaf approaches one or other of the discs, according as they are connected with one or other terminal. This new instrument is already coming into use: Mr. Watkins has constructed several.

February 25th.

On the Electrolysis of Secondary Compounds. By J. F. Daniell, Esq., D.C.L., For. Sec. R.S., and Prof. Chem. King's College, London: and W. Millar, M.D., Demonst. of Chem. at same College.

The authors of this paper have followed up their enquiry into the

Digitized by Google

phenomena of electrolysis, commencing from the point to which it had been carried by Prof. Daniell, in his papers published in the Phil. Trans. for 1839 and 1840. He had there shown that, in the electrolysis of neutral saline solutions, if the metal is one of those which do not decompose water at ordinary temperatures, it is precipitated in the metallic state at the platinode; but if it belong to the class of those which, at ordinary temperatures, do decompose water, then an equivalent of the oxide is liberated at the platinode, while an equivalent of hydrogen makes its escape in the gaseous form from the same electrode; the acid, in both cases, being, at the same time, liberated at the zincode, accompanied by an equivalent proportion of oxygen. On comparing these results with those of an independent voltameter, included in the same circuit, it was found that a certain definite proportion of the force, which resolves a single equivalent of a *simple* electrolyte into its anion and cation, produces the resolution of a full equivalent of a *complex* electrolyte into a simple metallic cation and a compound anion. When ammoniacal salts in solution were thus decomposed, ammonia, with an equivalent of hydrogen, was liberated at the platinode; while the acid, with an equivalent of oxygen, was evolved, as before, at the zincode.

Experimental evidence was thus obtained in support of two important theories,—namely, the ammonium theory, advanced by Berzelius; and the binary theory of salts propounded by Davy; in which latter theory, all saline compounds are regarded as being formed on the type of the hydracids. This binary composition of salts is, in the present paper, proved to exist, not only when the salts, previously held in solution by water, are decomposed by the voltaic current, but also when the fused anhydrous salt is electrolyzed: for example, metallic silver in crystals is deposited upon the platinode, when fused nitrate of silver is included in the circuit.

On examining by the current, monobasic, dibasic, and tribasic phosphates, the authors found that there were three distinct modifications of the acid transferred. From the monobasic phosphates, there was obtained the metaphosphoric acid; from the dibasic salts, pyrophosphoric acid; from the tribasic salts, the ordinary phosphoric acid was set free at the zincode. The acids were transferred into weak alkaline solutions, and recognized by their appropriate tests. The view entertained by Prof. Graham of the composition of these salts, is, therefore, completely confirmed.

On the other hand, the authors found, by similar experiments, made with the yellow and the red prussiate of potash, that only one compound of cyanogen with iron, or ferrocyanogen, as it exists in the yellow salt, is evolved at the zincode; and they not only converted the yellow into the red salt, by electrolytic action, but conversely reproduced the yellow from the red.

In pursuing their researches on double salts, a new order of facts were brought to light, which clearly proved that, although the two ions of the electrolyte are always *evolved* in equivalent pro-

Digitized by Google

portions, yet that they are not *transferred* in equivalent proportions to the respective electrodes; that some bases, such as copper, zinc, iron, and alumina, do not travel at all towards the platinode; that some, as magnesium, do so in small proportion only; and that others, as barium and potassium, are transferred in greater abundance; those whose oxides are most soluble appearing to travel most easily. On the other hand, the acids, whether forming soluble hydrates or not, seem all to travel toward the zincode, in proportions dependent principally on the nature of the base, with which they are united.

The curious phenomena, which have thus been brought to light, concur in establishing the general fact, that the disengagement of the cation and anion of an electrolyte in equivalent proportion is not always effected, as is commonly represented, by their simultaneous transfer in opposite directions, to their respective electrodes, in the exact proportion of half an equivalent of each; but that it is sometimes brought about by the transfer of a whole equivalent of the anion to the zincode, whereby a whole equivalent of the cation is left uncombined at the platinode, or by the transfer of unequivalent portions of each in opposite directions, making together a whole equivalent of matter transferred either to one electrode or the other; or, in other words, by the transfer of a quantity of matter capable of exercising one equivalent of chemical force; so that when the anion transferred to the zincode exceeds half an equivalent, the cation, transferred to the platinode, is, in an equal proportion, less than half an equivalent, and *vice versa*; the anion and cation set free being always in equal proportions. In no case, however, has there been observed the transfer of a whole equivalent of the cation to the exclusion of the anion.

These facts, the authors conceive, are irreconcilable with any of the molecular hypotheses, which have been hitherto imagined to explain the phenomena of electrolysis.

April 18th and 25th, 1844.

On the production of Ozone by Chemical Means. By Professor Schoenbein, of Bâsle.

The author conceives that of the two gaseous principles produced during the slow action of phosphorus on atmospheric air, and which have opposite voltaic characters, that which exerts electro-positive properties is composed of vapourized phosphorus, conjoined with particles of phosphatic acid; and the other, which is electro-negative, is identical with *ozone*, or the odoriferous principle disengaged at the positive electrode during the electrolysis of water. His opinion is founded on the odour of the one not being distinguishable from that of the other. He adduces further evidence in support of his opinions relative to the identity of the odoriferous principles during electric discharges in common air, during the electrolysis of water

Digitized by Google

and during the slow action of phosphorus upon atmospheric air. This principle, termed *ozone*, he regards as being a simple body and a constituent of azote, which he believes to be a compound of hydrogen and ozone; and he explains the disengagement of this latter element, which he considers as analogous in its chemical characters to chlorine, by the partial decomposition of azote, in consequence of its hydrogen combining with oxygen, in the several processes above mentioned, during which ozone makes its appearance.

ROYAL INSTITUTION.

April 26th.

Dr. Millar lectured on the Recent Researches in Electro-Chemistry, which had been communicated by himself and Professor Daniell to the Royal Society.* He gave an outline of the theories of electrolysis, and of Mr. Daniell's former researches on the electrolysis of secondary compounds. He then examined the questions whether, in metallic solutions the evolution of metal at the cathode is an immediate or a mediate result; and he gives the experiment, in which the reduction of silver or other metal is effected by immersing into their solutions charcoal, the pores of which had previously been filled with the hydrogen of electrolysis, as the strongest in favour of secondary action. On the other hand, fused nitrate of silver or nitrate of potash are directly electrolyzable, yielding at the cathode metallic silver or potassium, and at the anode nitric acid, *plus* one equivalent of oxygen. From these and other experiments Dr. Millar and Mr. Daniell believe that the metal is directly eliminated from its solution by the voltaic current, and is not the result of secondary action. Another point brought forward in their communication was the fact of some bodies when electrolyzed travelling in a definite direction, *i. e.* passing from anode to cathode, and *vice versâ*, while other bodies are not transferred. Tables of each of these classes of bodies were given. Our readers will be more at home with the subject of this lecture, when we give them in a future number a full abstract of the original memoir.

REVIEWS AND NOTICES.

Descriptive Catalogue of Magnetic, Electro-Magnetic, Electro-Dynamic, and Magneto-Electric Inductive Instruments and Apparatus, Constructed and sold by Watkins and Hill. Illustrated by 96 engravings. London, 1844, pp. 16.

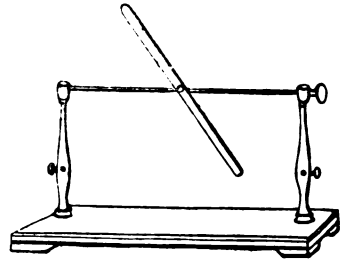
This Third Part of Mr. Watkins's Catalogue is as well worthy of being in the hands of all Electricians, and of the lovers of Science

* Vide p. 381 of present No. of Elec. Mag.

Digitized by Google

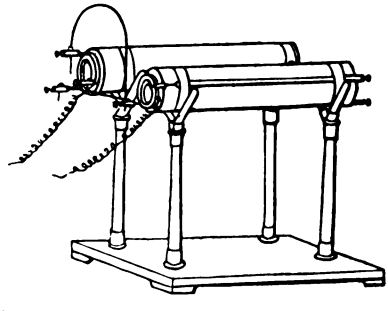
generally, as the earlier parts. The plan of arrangement is of course the same. The following very useful instrument deserves being every where known.

"Apparatus to exhibit Œrsted's Elementary fact in Electro-Magnetism. It consists of a horizontal metallic wire, capable of being turned on its axis, while forming part of the conjunctive wire of a voltaic battery. The magnetic needle is attached to the wire, with free motion in a plane parallel with it; so that, when the electric current pervades the wire, the deflection of the magnetic needle will be the same in all positions of the revolution of the wire on its axis."

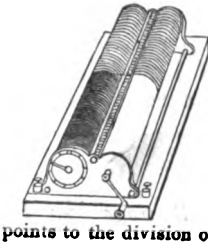


Press of matter has hitherto prevented our giving Dove's paper, in which the following, among other instruments, is described. We will make free for the present, with Mr. Watkins's Catalogue for this instrument; and also for Prof. Wheatstone's Rheostats, which have been described in a recent number of the *Electrical Magazine*.

"Dove's Differential Inductometer; consisting of two similar hollow wooden cylinders, surrounded by exactly the same length and thickness of stout insulated copper wire; each primary coil is enveloped by a secondary wooden cylinder coil of long fine wire of equal length and dimensions. The object of the apparatus is to exhibit the comparative inducing effects produced by inserting within the hollow wood cylinders, various forms of ferruginous and other metallic bodies; the results of which are extremely interesting, and rendered evident by the aid of a delicate galvanometer."



"Wheatstone's Rheostat* for adjusting and regulating an electric circuit, so that any constant degree of force may be obtained. It consists of wood and metal cylinders with parallel axis and a fine metallic wire which can be coiled or uncoiled on to, or off from either cylinder, by which means the electric current passes along the coils on the wood cylinder but only from the two points of the wire, which are in contact with the metal cylinder; therefore, the effective part of the length of the wire is the variable portion on the wood cylinder. A scale is placed to measure the number of coils unwound; and the fractions of a coil are determined by an index, which is fixed to the axis of one of the cylinders, and points to the division of a graduated circle."



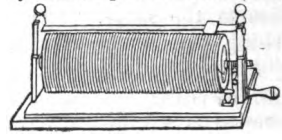
"Wheatstone's Rheostat† for regulating voltaic currents of comparatively small

* Vide Elec. Mag. No. 3, p. 203, § 5.

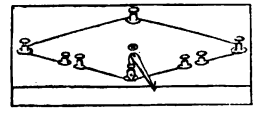
† Ib. p. 204, § 6.

Digitized by Google

resistances. It consists of a wooden or slate cylinder, upon which a thick copper conducting wire is coiled, like the thread of a screw. A fixed metal bar arranged parallel to the axis of the cylinder, carries a sliding spring piece, constantly pressing against one of the coiled wires. By turning the handle the cylinder revolves, and according to the direction either lengthens or shortens the conducting portion of the copper wire coil, which produces a corresponding difference in the resistance of the electric current."



"Wheatstone's Differential Resistance Measurer,* of metal wires and other conductors of Electricity. This apparatus is applicable to any galvanometer, and consists of a mahogany base-board, with an arrangement of four wires and brass binding screws, so that two galvanometer wires may be placed in the electric circuit. A contrivance is supplied for restoring the equilibrium produced (?) by slight differences in the lengths of the wires."



The real nature of the Electric Fluid; explained and illustrated by numerous facts, and a cause assigned for the polarity of the Magnet, &c. By JAMES GLENN. New Edition improved. New York, 1844, pp. 32.

THE author of this appears to have here and there caught sight of Electrical papers; and, we presume that in the ardour of youth, he has thought he could see further than the philosophical world, with whom he cannot yet be numbered; and the result of his vision is the above-named pamphlet. He is entering on the deep things of science before he has mastered the alphabet; beginning, in fact, at the wrong end, and theorizing when he should be storing his mind with the fact and philosophy which have been accumulated by the toil and research of others. We should advise him to make himself well master of the whole case, and then, if he pleases, to theorize anew.

We plead guilty to so much obtuseness of intellect as to rise from these pages quite as ignorant as ever of the "real nature of the Electric Fluid." The author calls it an *acid*,—"an extremely subtle acid, and that during a thunder-storm it is generated or evolved by the decomposition of a number of gases or vapours, that have exhaled from the earth and collected in the atmosphere in warm weather." However, we must not consume the time of our readers, on this "rudis indigestaque moles."

NEW BOOKS.

Beiträge zur Phofitalifchen Chemie, von C. F. Schönbein, Basle, 1844, *Brochure*, 8*vo.*—*Proceed. of American Phil. Soc. vol.* 3. *No.* 27. 1843, 8*vo.*—*Saggi dell Elettro-Magnetico, e Magneto Elettrico; Zantedeschi, Venice*, 1839; 1 *vol.* 8*vo.*—

* Elec. Mag. p. 208, § 16.

Digitized by Google

Recherche sul Termo-elettricismo Dinamico, e Luci-Magnetico ed Elettrico, Zantedeschi, Milan, 1838; 1 *vol.* 8*vo.*—*Notizie Elettriche, Dr. Elice, Genoa,* 1844, *Brochure,* 8*vo.*—*Archives de l'Electricité, No.* 13, *Genoa,* 1844, 8*vo.*—*Annalen.*—*Annals of Meteorology and Terrestrial Magnetism, Lamont, Munich,* 1843; *Nos.* 6 *and* 7. 8*vo.*—*On the Real Nature of the Electric Fluid, James Glenn, New York,* 1844, *Broch.* 8*vo.*—*Catalogue of Magnetic, Electro-Magnetic, Electro-Dynamic, and Magneto-Electric Inductive Instruments, &c., Watkins and Hill, London,* 6*d.*

NOTICES OF EXPERIMENTS, &c.

Electrolysis.—Mr. Connell, in order to detect whether the copper deposited in diaphragms is the result of direct electrolysis or of secondary action, devised an experiment, in which the respective solutions were iodate of magnesia with a little starch on one side, and solution of starch only on the other. On acting upon this with 36 pairs of four-inch plates, having the positive electrode in the iodate solution, blue matter mixed with magnesia appeared on the iodate side of the diaphragm. The action, which produced this, he thus describes:—"I conclude, therefore, that the whole of the hydrogen, arising from directly decomposed water, did not succeed in uniting with the oxygen coming in the opposite direction from the other side of the diaphragm, and that the obstacles to this union gradually increased as magnesia continued to be drawn towards the diaphragm and to be deposited in its pores, and ultimately on its surface. This hydrogen, so escaping combination, united in its nascent state with the oxygen of iodic acid, and set the iodine free, producing the usual blue compound with starch."...."The explanation seems to be that a trifling obstacle is afforded by the accumulation of a concentrated solution....in the pores of the diaphragm on its positive side to the union of the hydrogen and oxygen passing in opposite directions." This and other experiments induce him to believe that the membrane first opposes the entire union between the respective elements of water, and the reduced oxide opposes a further obstacle, and enables the nascent hydrogen to reduce the metal.—*Phil. Mag.*, March, 1844.

Melting of a Watch in the Pocket of a Man struck by lightning, without his being injured.—During a violent thunder-storm, a fishing boat, belonging to Midyell, in the Shetland Islands, was struck by lightning. The electric fluid came down the mast, which it tore into shivers, and melted a watch in the pocket of a man, who was sitting close by the side of the mast, without injuring him. Not only was the man altogether unhurt, but his clothes also were uninjured; and he was not aware of what had taken place, until, on taking out his watch, he found it all fused into one mass.—*Jameson's Journal,* Athenæum, Jan. 20, 1844.

Digitized by Google

Thermo-Electrical Battery for Electro-plating.—Mr. Poole, a recent patentee for "improvements in the deposition of metals" thus describes his electro-motive apparatus:—"I take 100 pieces of German silver, containing 20 to 25 [per cent?] of nickel, and 100 pieces of iron, every piece being 1 inch wide, 1 ft. long, and $\frac{1}{8}$ in. in thickness. These 200 pieces are soldered so to each other that iron is always combined with German silver. To get a compact form, I arrange, first, ten rows, every one of 20 pieces or 10 pairs; and solder these rows so to each other that they are parallel, and the whole take the form of a square, taking care that the several pieces are soldered together in such a way that iron will always be in connection with German silver. When the whole is united, I place it into a rim or frame of iron plate, 1 ft. 2 in. high; but so that the metals do not touch each other, nor the iron rim or frame, and fill the rim with plaster of Paris or clay, but so that all soldered parts of the series of plates or bars are uncovered, that is, the under ends 1 inch, and the upper ends 3 inches. The clay is covered at the [upper?] surface with a layer of pitch. The frame containing the series of bars on plates is so placed that the lower ends of the series, (1 inch) dip into a sand-bath, which is heated nearly to redness by the fire; the upper ends (3 inches) are to be kept as cold as possible; and, for this purpose, I cause a current of cold water to flow from out a vessel over the battery, to another vessel; the upper end of the metals (3 inches) may be covered with lac or varnish. I have found this battery sufficient for general purposes; and probably one formed of 50 pairs only would answer the purpose when small articles only are required to be coated."

He employs the following solutions:—

"*Silver Solution.*—I dissolve 1 lb. troy of silver in nitric acid, and dilute with 1 gallon of water, precipitate the silver, by adding a solution of carbonate of soda (in water) of 100° Fahr., (1 lb. of carbonate of soda is sufficient, if the nitrate of silver contains no free acid.) I wash the precipitate with warm distilled water and filter. In another vessel, I dissolve 8 lbs. of hyposulphite of soda in $2\frac{1}{2}$ gals. of water, at 100° Fahr. or thereabouts, and add thereto 1 lb. of carbonate of soda with the precipitated carbonate of silver, stirring the same until the silver is redissolved, which will be the case in a few minutes, and filter the solution, which will then be fit for use.—*Note.* In practice I have found it advisable that the solution contain free hyposulphite and carbonate of soda: and, for this purpose, I add 1 lb. avoirdupois hyposulphite, and $\frac{1}{3}$ lb. of carbonate of soda, in proportion to every pound troy of silver that may be deposited.—*Note.* In place of hyposulphite of soda, hyposulphite of potash may be used in the proportion of 5 lbs. of hyposulphite of potash, to 1 lb. of silver in the state of carbonate; and, in working the same, I add 6 oz. of hyposulphite of potash, and 5 oz. of carbonate of soda to every 1 lb. troy of silver deposited therefrom.

Digitized by Google

"*Another Mode.*—I prepare a solution of silver, as above, and boil the same for one hour, during which time a portion of silver is precipitated, and the hyposulphite changes, forming a new and distinct salt. The solution is filtered, and is then fit for use."

"*Gold Solution.*—I dissolve 1 oz. troy of fine gold in nitro-muriatic acid, and evaporate the solution, until it assumes a deep red colour, and crystallizes upon cooling. I then dilute the remaining solution with one pint of distilled water, and filter; I then heat the clear solution of gold to about 200° Fahr., and precipitate the gold by adding a solution of liquor ammoniæ; I then pour the precipitated gold upon a filter, and wash it several times with hot water; I then dissolve this precipitate of gold in a gallon of water, containing 8 oz. hyposulphite of soda or an equivalent quantity of potash, and boil the same together for one hour; I then filter the solution and it is fit for use. During the process of gilding, I prefer to warm it to about 100° or 150° Fahr. In using the above, I employ a small anode of gold, say about $\frac{1}{10}$th the size of the article to be gilt, and a current of two pairs of plates, (if I employ the ordinary galvanic battery,) but this effect may be varied by altering the power of the battery, and the size of the anode at the pleasure of the operator."

"*Copper Solution.*—I dissolve 1 lb. carbonate of copper in 8 lbs. hyposulphite of soda, (or an equivalent of potash,) and 1 lb. carbonate of soda, dissolved in $2\frac{1}{2}$ gals. distilled water at 100° Fahr., or thereabouts; and filter to obtain a clear solution. It is then fit for use with currents of electricity, and I prefer to use it at 100° Fahr."—Sealed May 25; Specified Nov. 25, 1843. —*Mech. Mag.*, Jan 6. 1844.

Priestley's Spots.—M. Matteucci has obtained spots similar, but on a smaller scale, to those described by Priestley, by presenting Daguerréotype plates to a point proceeding from the prime conductor of a machine; they are commonly circular, of a blackish colour, and two or three millimetres in diameter, seeming to occupy the base of the luminous cone, constituting the spark. Variation in the body from whence the spark is drawn, or of the medium through which it passes, does not alter the result. If the spark is repeatedly passed, prismatic colours may, by means of a lens, be detected embracing the exterior of the spot. On passing a charge from a battery of 12 jars, through two Daguerréotype plates, nothing similar was obtained; but very beautiful stars, of a yellowish colour, were formed.—*Compte Rendu*, 17 *April*, 1843.

Electric Flame.—Mr. Bunsen more than doubles the intensity of light between the charcoal points from a voltaic battery, in using charcoal prepared by being frequently soaked in a concentrated solution of sulphate of soda. M. Reizet suggests that the same exalted effects might follow the employment of solutions of salts with an earthy alkaline base.—*Ann. de Chim.* May 1843, p. 32.

Weak Loadstones improved.—M. Billand heated a piece of loadstone to redness, and then placed it in contact with a small electro-

Digitized by Google

magnet, until it became cold. The magnetism thus exalted has suffered no sensible diminution during six years.—*Compte Rendu*, 7 Aug. 1843.

Physical Science in England.—"According to the present patent laws, it is more than questionable whether the discoverer of a great scientific principle could pursue his own discovery, or whether he would not be arrested on the threshold by a subsequent patentee; if Jacobi lived in constitutional England, instead of despotic Russia, it is doubtful if he could work out his discovery of the Electrotype,—we say *doubtful;* for, as far as we can learn, it seems hitherto judicially undecided whether the mere use of a patent, not for sale or a lucrative object, is such a use within the statute of James, as would be an infringement of a patentee's rights. It appears to be settled, that a previous experimental and unpublished use by one party, does not prevent a subsequent inventor of the same process from patenting it; and, by parity of reasoning, we should say, that if a party have the advantage of patenting an invention which can be found to have been previously used, but not for sale, he should not have the additional privilege of prohibiting the same party, or others, from proceeding with their experiments. . . . Even could the patent laws be so modified, that the benefits derived from them could fall upon those scientific discoverers most justly entitled, we are still doubtful as to their utility, or whether they would contribute to the advancement of science, which is the point of view, in which we here principally regard them. It would scarcely add to the dignity of philosophy, or to the reverence due to its votaries, to see them running with their various inventions to the patent office, and afterwards spending their time in the courts of law, defending their several claims. They would thus entirely lose the respect due to them from their contemporaries and posterity; and waste, in pecuniary speculation, time which might be more advantageously, and without doubt, more agreeably employed. If parties look to money as their reward, they have no right to look for fame; to those who sell the produce of their brains, the public owes no debt.

"We have observed recently a strong tendency in men of no mean scientific pretensions to patent the result of their labours. We blame them not: it is a matter of free election on their part, but we cannot praise them."—*Blackwood*, Oct. 1843.

Applications of Electro-magnetism.—"I have also invented and constructed a modification of this instrument, by which means a thermometer, while permanently placed at any depth beneath the surface of the soil, may be read at the surface. Finally, I have carried my electro-magnetic chronoscope to a high degree of perfection; and I have employed it to measure the swiftness of musket-balls through different distances and with different charges of powder."—*Prof. Wheatstone to Prof. Quetelet.*—*Bull. Acad. Brussels.*—May 5, 1843.

Atmospheric Electricity.—The Brussels Academy have awarded

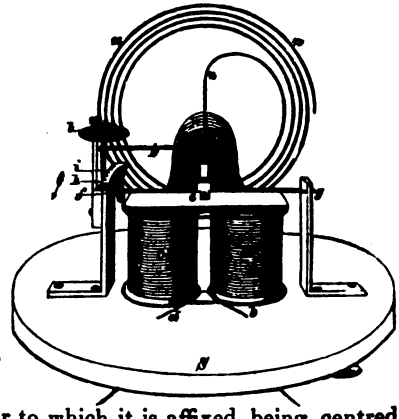
Digitized by Google

a gold medal to M. F. Duprez, of the Athenæum at Ghent, for a memoir on atmospheric electricity.

Steel for Magnets.—M. Kupffer of St. Petersburg thus writes to M. Quetelet:—"I have again taken up my investigations respecting the influence of heat upon the magnetic intensity of bars, directing them toward a practical end, that of contriving magnetized bars, the power of which should not vary with the temperature, within certain limits, at least; and I have already succeeded in fabricating a character of steel, over which temperature exercises scarcely any influence, or else an influence of a negative character, that is, the magnetic force of which increases with the temperature."—*Bull. Acad. Brussels.*—July 2, 1842.

Electricity of Mountains.—M. Peltier writes in reference to observations lately made by him at Faulhorn:—"Isolated mountains are true points attached to an electrized body, where the tension is prodigious, and whence electricity is given off in an abundance, which renders the greater number of our electrometers much too delicate. In my opinion, there cannot be any doubt as to the cause of the electricity of waterfalls, or of mountain mists, or in fact, as to the colour of the vapours which arise thence,—a colour, which I could predict, as well as their transformations from grey to white or from white to grey."—*Bull. Acad. Bruss.*—Oct., 8, 1842.

Lockey's Signal Apparatus.—The Rev. Mr. Lockey having kindly communicated to me a drawing and description of an ingenious electro magnetic *signal* or *bell striking* apparatus of his invention, I feel much pleasure in here giving it publicity. On the base board S, is fixed the electro-magnet *c, d*, its terminal wires *a, b*, pass through the base board, and lead off to the poles of the exciting battery.



The armature *e*, is prevented from actual contact with the magnetic poles by an interposed piece of leather. The armature is capable of slight angular motion (*i. e.* like the lid of a box,) the bar to which it is affixed being centred at *f* and *g*. At the end towards *f*, a toothed segment of a circle *h*, is fixed, which, when the armature is attracted by the electro-magnet, traverses in the direction of the arrow near *h*. The toothed segment acts on the *pinion wheel i*. On the axis of this pinion, and at right angles to it is fixed the arm *k*, carrying the hammer *k*. The stroke of the hammer is given on the central stem (and interiorly) of the French bell spring *n, n, n*, a piece of leather being dove-

Digitized by Google

tailed in the edge of the hammer to give mellowness to the tone, which, if the spring be about five inches in diameter, will have the effect of an abbey clock striking at a distance.

This spring is firmly fixed by a square piece of brass to a block of wood at *o*, this block being also firmly attached to the base board.

On the contacts with the battery being completed, the armature descends and the hammer is withdrawn. Contact being broken, the hammer stroke is given under the influence of a light spiral watch-spring contained in the box *m*. By means of a ratchet wheel and catch at the bottom of the box *l*, this spring at the bottom can be slackened and tightened, and thus regulated exactly to the power of the battery used. The ingenious mechanism of this part of the apparatus was contrived by a talented young watch-maker of Bath, Mr. George Wadham. By means of the contact-breaker applied to the bell-hammer of an ordinary eight-day house clock, his apparatus will synchronically strike the hours in any apartment of the house in which it can be interposed in a galvanic circuit.—*Noad's Elect.* p. 443.

Wollaston on Deposition of Metals.—"Wollaston's experiment here alluded to is that in which copper was deposited on the negative wire and re-dissolved on reversing the connection."—*Phil. Mag.* 3rd Ser. Vol. ii. March 1833.—One step further and the Doctor would have hit upon the Electrotype.—[From a correspondent.]

Electro-Telegraph.—Some experiments have been tried between Nine Elms and Wimbledon with Mr. Bain's Telegraph, by means of buried plates, one being at each terminus, a distance of six miles, and each presenting a square foot of surface. The electric developement was active with this interval between the positive and negative metals.

Exaltation of Electro-motive force.—Poggendorff arranges a certain number of pairs of platinum electrodes so that one half are connected with the zinc and the other half with the platinum of a Grove's-Battery; as the current polarizes them, he detaches them and so alters the connections as to form them into a series; and thus the secondary currents arising from the initial polarization are associated in a series, and a current of exalted tension is produced. The principle, so far as we can comprehend it, is somewhat the same as that described by Grove. (Vide Elec. Mag. p. 314.)

Electro-specula for telescopes.—"His own idea (H. Fox Talbot's) was that it might be possible to whiten the surface of the copper, without injuring the form; and, therefore, having obtained a speculum in very bright polished copper, he whitened it, and transformed it into sulphuret of copper, by exposing it for a minute to the vapour of hydro-sulphuret of ammonia, which did not injure its polish, but, after passing through a series of varied colours, (scarlet, blue, &c.) rendered it very white; and, after having retained this speculum about a year, he did not perceive the smallest alteration in any respect. Prof. Steinheil precipitated

Digitized by Google

gold upon the speculum, which was to be copied, and having precipitated a certain thickness of gold, he then precipitated copper on the back of the gold, to give it sufficient thickness. He first precipitated gold from the cyanide of gold, and he mixed with it cyanide of copper, and kept gradually increasing the quantity of the latter, so that an alloy was precipitated, which was continually increasing the copper with respect to the gold, till he had a speculum, whose surface was gold, and which then became an alloy, the quantity decreasing till, at the bottom, it became pure copper. This was important, because, without such experiments, one would not have known that such results would have followed, for some philosophers supposed that, if we attempt to precipitate the salts of two metals, only one is precipitated; but Professor Steinheil informed him that they precipitated in union."—Report of British Association for 1842.

Immersed plates.—"The experiments were performed on the Chain Pier, Newhaven, which projects into the sea nearly 600 feet, on Wednesday the 5th August, 1829, in presence of Captain Thomas Brown, and Messrs. Cheek and Ainsworth.

"A plate of copper and one of zinc were prepared, 12 inches square. A copper wire was then soldered to each of them, 200 feet in length. Fine platinum wires were also soldered to the extremities of each of the copper wires. The plates being thus prepared, two of the gentlemen who assisted me, stood on the pier, at a distance of nearly 300 feet from each other, one of them having the copper and the other the zinc plate, who were ready at a given signal, to immerse them into the sea by the wires that were attached to them. The wires were continued along the pier, so as to meet in the middle to complete the circuit, at equal distances from the plates, where the experiments were performed." Then follow the experiments in detail.—K. T. Kemp, Edin. Jour. of Nat. and Geogr. Science, No. 1, Oct. 1829, p. 15.

Electrical safety-lamp.—The light from the charcoal points, contained in a closed glass, has been proposed, and has been tried for illuminating coal mines.

*Action of Buried Plates.**—"Three months additional trial, shows *very great* steadiness of action; the galvanometer almost invariably indicates 51° or 52°, though a few days ago, during unusually *cold* weather, with a *strong* N.E. wind, the indication *increased* to 55°, and still remains at 54·5°. I do not connect this increase with the temperature of the wind, being satisfied with its connection with the oxidation of the zinc plates; and I expect that, when we are permitted to have some rain, the deviation will be increased. I should mention that very soon after I wrote to you on the 8th of March, I *increased* the *number of plates* from 16 to 24; so that ever since that increase, the surfaces have been thus, viz. of zinc 133 square ft., and of copper about 115 square ft. (single surfaces); so that the whole surfaces in action may be

* Vide Elec. Mag. No. 4. p. 279.

Digitized by Google

reckoned, instead of 290 square feet, as before, at about 470 square ft. The greatest weight this has sustained is only twenty-eight pounds."—Rev. F. Lockey to the Editor, May 24, 1844.

Galvanoplastic.—The Prince Bagration has detailed experiments, in which he shows that the metal gold, especially if in a state of minute division, is soluble in Liebeg's simple cyanide of potassium. He placed the gold in powder, obtained from the auric chloride, in a solution of the above salt, which he electrolyzed by a platinum anode and a copper cathode, and obtained a deposit of gold, which was the test of its presence in solution. Heat facilitates the solution, and gives a liquid capable of giving reduced gold or copper or silver with voltaic aid. The yellow ferro-cyanide possesses the same properties, but in an infinitely less degree. The ferro-salt dissolved a plate of gold, by the aid of a heat of 100° to 120° Fah. in three days. The prince says, in reference to these experiments, "If it were allowable to advance an hypothesis, we might be tempted to suppose that the gold is found in these solutions in a state of cyanate or ammoniate, in consequence of the numerous transformations, which the cyanurets experience when in contact with the air."—L'Institut, 22nd Feb. 1844.

Galvanic Daguerréotype Plates.—"The galvanic plates, when free from clouds and black spots, (which sometimes occur in the original) receive the application of metals better than others; and, consequently, as the chloride of gold adheres to them more strongly, it does not scale off."—Daguerre, Comptes Rendus, April 22, 1844.

Magnetism Extraordinary(?).—In the pages of the "Bristol Mirror," was inserted a letter, evidently a hoax on the credulous editor, but which has been reprinted without comment in some journals, and elsewhere, with observations favourable to the promises it holds forth. It contains a suggestion for elevating the Great Britain steamer by means of electro-magnetism, or as it is represented by the writer of the letter, "Concentrated Electro-Magnetism." He says, "My condensed magnet, for such I propose to call it, is, in proportion to its power, of a very small bulk; and, with a very small instrument, I have bent a lamp-post, by fixing the magnet on the other side of the street." We can excuse our readers for being a *little* sceptical on this matter. If they are patient, an opportunity will be one day afforded them, (at least so says the printed column,) of seeing and believing. "It is my intention," says the writer, "shortly to exhibit the magnets in full operation, either at the Polytechnic or other suitable building, when I will, by their means, suspend a cube of iron, three feet square, like the coffin of Mahomet, between earth and heaven." We will not neglect fully describing the magnets, *when they arrive* at the Polytechnic; till then, we must continue to believe lamp-posts to be in the condition of the said Mahomet's mountain, to which he had to go, for it would not come to him.—Ed.

Digitized by Google

ELECTRICAL MAGAZINE.

October, 1844.

LXI. *Remarkable Instances of the Protection of Certain Ships of Her Majesty's Navy, from the Destructive Effects of Lightning.* Collected from various authorities, by W. Snow Harris, F.R.S., &c. Communicated by the Author.

The Official Journals of the British Navy present, from the earliest period of its history, melancholy and often fatal instances of the destructive action of lightning. In about 200 cases only, the amount of money sunk on account of masts and other material, ruined or destroyed, cannot be set down, on a moderate computation, at less than 100,000*l.* Three hundred seamen either lost their lives or were seriously injured, and the country was frequently deprived of the efficient services of its ships and fleets, at critical periods. Between the years 1810 and 1815, we find records of no less than 35 sail of the line, 13 frigates, and 10 sloops, either disabled or greatly damaged.

A want of due attention to the means of parrying the force of the electrical discharge, may be considered as the more immediate cause of so much havoc. Our ships have either been unprovided with Lightning Conductors altogether, or if furnished with them, they have been of such small capacity, so partially and ill-applied, and so dependent on the prejudices of sailors, for due care and attention to them, that little benefit seems to have been derived from this source of protection.

From the circumstance of a ship being constantly exposed to the action of violent storms, and other mechanical forces, almost every practical seaman contended, that if Lightning Conductors were employed on ship-board at all, they should

Digitized by Google

be applied under some fixed and permanent form, so as to render them perfectly secure, and independent of the crew of the ship; who would be thus relieved from the necessity of handling and watching the Conductor, to their great peril and annoyance, in heavy gales of wind and thunder storms. A small wire, or linked chain, applied as rigging, would not, as is evident, be likely to stand long in a gale, which could blow the sails into shreds, and carry away some of the spars altogether. But then the question arises, how is this to be effected so as to meet all the variable conditions of a ship's masts, and all the casualties in which the ship itself might become placed ?

To meet this case, the author of these remarks proposed in the year 1820, to give a ship a perfect conducting power throughout, by incorporating with the masts, continuous plates of copper, connecting these with all the principal metallic bodies employed in the construction of the hull, and with the sea, thus bringing the general mass into the electrical position it would assume, supposing the whole fabric were metallic throughout. Certain discoveries and enquiries into the Laws of Electrical Action, which he had commenced at this period, backed by observations on a great variety of instances, of the course of lightning on ship-board, fully showed that this might be done with perfect security, and that in whatever position the sliding masts might be placed, a discharge of lightning falling on them, would certainly become dispersed upon the sea, without any deviation or intermediate explosion. This being demonstrable, it remained only to perfect the mechanical detail, and apply the Conductor along the spars, in such way as to render it consistent with the flexure, strain, and other mechanical contingencies, to which they are subject. Thus the Conductor became an integral part of the ship and masts, and the vessel consequently made secure in itself, at all times and under all circumstances, against the violent explosive effects of lightning, without the necessity of any interference whatever, on the part of the crew.

This method of defending shipping from lightning, may be considered as the most extensive application of the general principles of Lightning Rods, ever attempted. It has been gradually, and is now commonly resorted to in H. M. Ships, and with the most marked success; not only has it been found that the ships thus fitted have, by the silent action of the Conductors, come with perfect safety out of the most severe thunder storms, in all latitudes and climates, but even in cases in which very heavy thunder and lightning has

Digitized by Google

actually burst on the masts, still not the least ill consequence has ensued; the electrical discharge having been dispersed from the instant of its striking on the Conductor.

These instances, which may in fact be considered as so many experiments on Lightning Rods, made on the great scale of Nature, appear of too much importance to the public interest, and to science generally, to be passed by; they have hence been briefly stated in the few following pages.

Actæon, 26.

This ship, during the years 1840 and 1841, was repeatedly exposed to lightning storms in tropical and southern latitudes. The following is a very important and clear account of the phenomena of a burst of lightning and thunder on the masts of this vessel, and the protecting effect of the Conductor, as given by Lieut. Bonham, then officer of the watch.

"When off the coast of Central America, in H.M.S. *Actæon*, on the morning of the 23rd July, 1841, I, being officer of the middle watch, having heavy squalls of rain, thunder, and lightning, had shortened sail, and was running with square yards, wind to the eastward, sky very dark. Whilst standing on the larboard side of the quarter deck, between the main-mast and binnacle, and looking towards the main-top, a most tremendous clap of thunder burst over our mast-heads, the lightning appearing at the same time to run down the Conductor. There was no interval of time that I perceived, between the flash and the report of the thunder, I saw nothing for several minutes after; the quartermaster of the watch, Henry Love, also observed it, and said to me afterwards, it was the sharpest lightning he had ever seen, and was surprised that we were neither of us injured by it. I believe the Conductor saved the mast, and probably some men's lives."

(Signed,) C. W. Bonham, late of H.M.S. *Actæon*.

Mr. May, the carpenter of the *Actæon*, states, that at the time the cloud burst on the ship,

"He was standing with his back against the pump winches, near the main-mast, when there came a crash of thunder directly overhead, as if the ship's broadside had been fired. He says it was an awful sound, and attended by a loud whizzing noise; the ship fairly shook under it. He felt the pump gear against which he was leaning, tremble; the cutlasses stowed about the main-mast rattled in the stand; a momentary vivid flash seemed to strike the Conductor, the effect of which on discharging the lightning, was truly beautiful. The night was awfully dark, with a heavy sea; no damage or inconvenience was experienced; he examined the conductors, as carpenter of the ship, after the squall, and found them quite perfect."

Digitized by Google

This was not the only instance in which the Conductors saved the *Actæon* from damage.

Asia, 84.

The following is the account given by Mr. Sadler, Master, R.N., of a stroke of lightning which fell on this fine ship, in the Tagus, in November, 1831, but which was instantly dispersed by the Conductor.

"At the close of the day a gale set in from the west, accompanied by clouds, with rain, thunder, and lightning; during a heavy squall, and whilst standing under the poop awning, in conversation with Capt. Hyde Parker, a sudden flash, with an instantaneous clap of thunder, burst over us. I was convinced that the main-mast had been struck, but being fitted with Mr. Harris's Conductors, we experienced no inconvenience. I have always felt satisfied that, had we not been so fitted, our main-mast must have been shattered, and I think Capt. Parker was of the same opinion. No official report, however, was ever made upon the *Asia's* being struck by the electrical discharge."

Mr. Sadler, whose services are well known and appreciated in the Navy, is now the Master-Attendant at the Chatham Dock-yard; and no one acquainted with him, would for a moment question the accuracy of his judgment as a careful observer. It further appears that, in consequence of the thunder and lightning, the people were all sent below, the ship being at the time moored in the Tagus.

Beagle, 10.

The *Beagle*, during her late voyages in the Southern Hemisphere, was more than once struck by discharges of lightning. On one occasion, in the Rio de La Plata, the shock appears to have been very severe. Capt. Sullivan, then First Lieutenant of the *Beagle*, thus describes the phenomena he witnessed.

"I was First Lieutenant of the *Beagle*, and was attending to my duty on deck. The ship was at anchor off Monte Video, in the Rio de la Plata, a part of the world often visited by severe thunder storms. Having served in H.M.S. *Thetis*, a few years before, when her *foremast was entirely destroyed by lightning*, at Rio Janeiro, my attention became particularly directed to approaching electrical storms; on this occasion the storm was unusually severe. The flashes of lightning succeeded each other in rapid succession, and were gradually approaching. I was watching for them aloft, when the ship apparently became wrapped in a blaze of fire, accompanied by a simultaneous crash, which was equal to, if not greater than the shock I felt in the *Thetis*. One of the clouds, by which we were surrounded, had evidently burst on the vessel, and as the main-

Digitized by Google

mast, for the instant, appeared to be a mass of fire, I felt certain that the lightning had passed down the conductor, on that mast; the ship was shaken by the shock, and an unusual tremulous motion could be distinctly felt.

"So soon as I had recovered from the surprise of the moment, I ran down below to see if the Conductors there had been affected, and just as I entered the gun room, the purser, Mr. Rowlett, ran out of his cabin (along the beam of which a main branch of the Conductor passed), and said he felt certain that the lightning had come down the Conductor, for at the instant of the shock, he heard a vibrating sound, like rushing water, along the beam. Not the slightest ill consequence was experienced, and I cannot refrain from expressing my conviction, that but for the conductor the result must have been serious."

This occurred in August, 1832. Capt. Fitzroy, who commanded the *Beagle*, on his return to England, made the following Report to the Lords Commissioners of the Admiralty:—

"Previously to sailing from England, in 1831, the *Beagle* was fitted with the permanent Lightning Conductors invented by Mr. Snow Harris. During the five years occupied in her voyage, we were frequently exposed to lightning, but never received the slightest damage, although supposed to have been struck on *at least* two occasions.

"At each of these times, at the instant of a vivid flash of lightning accompanied by a crashing peal of thunder, a hissing sound was distinctly heard on the masts, and a strange though slightly tremulous motion in the ship, indicated that something unusual had happened.

"No objection, which appeared to me valid, was ever raised against them, and were I allowed to choose between masts so fitted and the contrary, I should decide in favour of those having Harris's Conductors; even in the small spars the plates of copper held their places firmly, and increased rather than diminished their strength."

Druid, 44.

The *Druid* is stated by Capt. Norcott, R.N., to have been in "awful lightning at Rio Janeiro," which was conducted without damage, "down the fore and main masts."*

Dryad, 44.

Capt. Turner, R.N., late of the *Dryad*, states in evidence,

"That in a tornado on the coast of Africa, both the fore-mast and mizen-mast were struck by lightning; the ship appeared enveloped in flames; the thunder was very loud, and instantly suc-

* *Vide* Shipwreck by Lightning, Report and Evidence, &c. printed by the House of Commons, February, 1840, p. 90.

Digitized by Google

ceeded the lightning." He further states, "that whilst standing on the quarter-deck, during one of the flashes, I distinctly saw the lightning run down the Conductor, on the fore-mast, and the officer on the forecastle came and told me, he heard a hissing noise, resembling the boiling of water; all the men heard it also. A short time afterwards, several of the officers standing abaft, saw it at the time of another flash, go down the mizen-mast, and heard the same hissing noise."

In allusion to the conductors, he adds, "carrying sail has no effect upon them; we carry a heavy press of sail sometimes."*

Daphne, 18.

A flash of lightning fell on this ship, off Monte Video, on the 9th February, 1843. Capt. Onslow, commanding the *Daphne*, reports to the Admiralty, that "it passed down the main-mast, and through the ship's side." No damage or inconvenience was experienced.

Minden, 74.

On the 30th of July, 1843, one of those violent thunder-storms, peculiar to a tropical latitude, occurred at Hong Kong. The electrical discharge fell twice on the masts of the *Minden*, 74, stationed there, the topmasts being partly lowered. Mr. Cook, one of the officers of the *Minden*, states in writing that

"Two flashes struck the ship and played about the Conductors, which conveyed away a stream of fire, awful to behold; a frizzing noise was distinctly heard." "Several merchant ships were struck by the lightning, four men killed, and some others wounded, and but for the Conductors in the *Minden*, the ship would have received serious injury."

One of the crew of the *Minden*, lately arrived in England, states that the spars of the merchant vessels were shivered by the lightning, and that the concussion of the thunder on the ship, was such as to convey to those below, the idea of the shock of an earthquake.

Racer, 18.

The *Racer*, commanded by Capt. A. Reed, was struck by lightning, at the Bucco, in the Rio de La Plata, on the 27th of February last, 1844.

The electrical discharge fell on the truck of the fore top-gallant-mast, the vane spindle which terminates the Conductor, being down for repair. It melted a portion of the

* Shipwreck by Lightning, Report and Evidence, &c. printed by the House of Commons, February, 1840, p. 29, and p. 48.

Digitized by Google

copper band round the truck, and then getting hold of the Conductor fixed in the mast, was immediately dispersed without inconvenience or damage. Capt. Reed thus relates the circumstance:—

"About 4, 30, A.M. during a heavy storm of thunder and lightning, the lightning was distinctly seen to run down the foremast, and upon removing the truck (which I have now in my possession), it was quite evident from a part of the copper rim round the truck being fused, that the lightning had entered there, passed along a bolt of one of the sheaves, and so communicated with the Conductor on the mast, which carried it safely off. We have shown the truck to many persons, who all speak highly in favour of the Conductors."

This is a direct case of the dispersion of an electrical discharge, which actually melted the metallic band in the place on which it first struck.

Scylla, 18.

This sloop was struck by lightning in the West Indies, August 6th, 1843, at 7,50, A.M. The lightning fell on the mast, and it appears by the log, was most effectually carried off, without any damage to the spars or hull. Capt. Sharpe, who commands the *Scylla*, thus describes the circumstance:

"On the morning of the 6th August, 1843, lat. 24° 3′ north, long. 69° 12′ west, the *Scylla*, at about 8 A.M. was struck by lightning attended with a heavy clap of thunder, which shook the ship to her kelson. The greater part of the morning watch had been one continued and heavy rain, the weather threatening and unsettled, sky overcast with dark clouds, wind unsteady, heavy thunder and lightning, both sheet and forked, and frequent explosions very close to us."

The ship was struck from a cloud densely charged with electric fluid, which overhung the masts; it was raining furiously all the time.

"The course of the lightning was from the main-truck down the main-mast, escaping through the ship by the various conductors connected with the mast for that purpose." Capt. Sharpe further observes, "there can be little doubt that our spars were saved by the Conductors, and from their being fixed, I consider them preferable to any I have ever seen."

This seems to have been an extremely powerful discharge, some of the butts of the copper-plates in the top-gallant-mast, were started by it, and in one place buckled up at the edges; some of the fixings also were shaken and loosened. Captain Sharpe states "that no other mast was touched, or felt the least effect from the shock," and that "the top-gallant-mast,

Digitized by Google

on which this occurred, was not fitted by the Dock-yard in England, but was prepared at Port Royal," where the most improved method of applying the Conductors to the spars, cannot as yet be known. The circumstance may be considered in an experimental point of view, as a very fortunate one, since it shows how violent a shock the Conductors are capable of discharging, without any heating effect being produced on them, and without any kind of inconvenience being experienced in the hull of the vessel, or by the Conductors themselves, when properly secured.

Mr. Welsh, the carpenter of the ship, and whose duty it is to inspect the masts, states, by permission of his captain, that,

"On examining the Conductor, after the ship was struck by lightning, I found it had started from a butt, about three feet below the truck, at the main royal mast head; it was again replaced in a few minutes," that "neither the ship nor the mast received any hurt or damage from the flash or the fluid," and gives it as "his true opinion, that had it not been for the conductors, the mast, if not the ship, must have sustained a serious injury."

It appears also by the ship's log, that such was the excited condition of the whole mass of the ship, and the air immediately under the thunder-cloud, that "various parts, such as the chain cables, coppers, &c. exhibited symptoms of electricity." It also appears by the log, that the ship having shortened sail, 6,30, A.M. to a heavy squall from S.W.," was "at 7,50, during a squall from N.W. struck by lightning" in the way above described. At 8,20, that is, within half an hour, they "made sail" again, and the ordinary duties of the ship went on as if nothing unusual had occurred.

Here then we have an instance of a ship rendered perfectly secure from the effects of lightning, in the focus of a tropical thunder storm, and under circumstances of a very threatening and dangerous kind; and which, as appears by the records of H. M. Navy, have, in a great variety of similar instances, been productive of the most fatal consequences.

Talbot, 20.

In July, 1842, H. M. Ship *Talbot*, having just completed her equipments at Sheerness, was proceeding to sea, when she encountered a thunder squall near the Nore. A dense cloud poured forth its lightning, attended by a crashy peal of thunder. The captain, Sir Thomas Thompson, observed it strike upon the Conductor, on the main-mast, by which it was instantly discharged without damage or inconvenience; at this

Digitized by Google

time the ship was under weigh, and the men employed about the ropes and sails, as usual on such occasions.

Communicated by Lieut. F. Harper, of H.M.S. *Daphne*, at the time of some electrical experiments on the *Daphne*, before the Lords of the Admiralty, at Chatham, August 17, 1842. Lieut. Harper was at the time alluded to in the *Talbot*.

In reviewing these instances of the preservation of certain ships of the British Navy, in thunder storms, it is impossible not to be struck with the concurrence of various individuals, in their accounts of the phenomena which they witnessed; and it is impossible not to be impressed with the importance of the fact, that these statements have been made by officers in H. M. service, at intervals of several years, quite unconnected with each other, and quite uninfluenced by any personal interest. The statements are made in plain but intelligible language, describing just what the observers witnessed, according to the common acceptation of the terms which they use, neither more nor less. Nothing, therefore, in the shape of evidence, can be more perfect.

There are a few interesting facts developed in the history of these cases, which it may be worth while briefly to notice.

First. The electrical discharge is said to have been attended by a peculiar whizzing noise, such as that produced by the escape of steam, or water boiling. Now this phenomenon has been also noticed in other instances of thunder storms at sea. Thus in the case of H. M. brig *Bellette*, 18, struck and damaged by lightning in the West Indies, in May, 1825. Capt. Leath, who commanded the brig, says, "as the lightning shot towards the earth, it caused a noise similar to the whizzing of musket-balls." In this case some of the spars were shivered in pieces, and thirty-six men struck down on the deck, five of whom were seriously injured.*

Secondly. The observers agree in stating, that the discharge is accompanied by a luminous stream, as if the lightning were running down the Conductor. This phenomenon was witnessed so long since as the year 1777. A heavy stroke of lightning fell on the Conductor of the Tower of Sienna, and several persons noticed upon it "a long and regular train of light."†

It is now known that this appearance depends on the electrical state of the particles of the air contiguous to the Conductor, which even after the great body of the charge has

* See Nautical Magazine for March, 1844, p. 162; or Meteorology of Thunder-storms, p. 57.

† Tilloch's Magazine, vol. viii. p. 318.

Digitized by Google

passed down it, continue to emit, for an evanescent portion of time, a luminous glow; thus conveying to the senses the idea of lightning running down the Conductor. The glow is of a perfectly harmless character, and may be easily produced artificially, by a discharge of common electricity over a wire placed in air a little rarified by the air-pump, so as to diminish the atmospheric pressure, in respect of the quantity of electricity discharged.

Thirdly. The luminous effects of a heavy discharge of lightning upon the mass of air surrounding the vessel, are again occasionally described as apparently enveloping the ship in flames, or some form of expression of this kind; thus Capt. Sullivan says the mast of the *Beagle* appeared in a blaze of fire.

We find a parallel instance recorded in Rozier's Journal, vol. 22, in which a circumstantial account is given of lightning falling on the Conductor of a powder magazine, in Silesia: "The flash was seen to leave the cloud and strike upon the rod; it appeared to envelope the whole building in electrical fire;" this appearance is also a consequence of the electrical state of the air at the instant of the discharge, and is very commonly observed in severe thunder storms. Like all other electrical phenomena of a purely luminous character, it is quite harmless; the danger in such cases arises only from the actual presence of the electrical agency, in the points through which it forces its way with repeated explosions, but which destructive action is, by the operation of a non-resisting and continuous line of metal, entirely obviated.

Fourthly. The violent concussion the observers describe, so common in the case of the electrical discharge striking elevated bodies, and the simultaneous descent of the lightning with the crash of the thunder, is particularly characteristic. "I could perceive no interval of time between the flash and the thunder," observes Mr. Bonham, in his account of the *Actæon;* thus also, Mr. Sadler, with respect to the *Asia,* 84, speaks of "the sudden flash and *instantaneous* clap of thunder." Other observers speak of the concussion as if the broadside had been fired, which is another characteristic of the electrical discharge falling on ships. Thus in the account of the damage done by lightning to H.M. Ship *Trident,* 64, it is said that "the electrical discharge burst over the ship with a crash as if the main deck guns had gone off." The same thing is stated in the instance of H.M. Ships *Clorinde,* 44, and *Egeria,* 20.*

Finally. It is important to notice the fact, that in the case

* Naut. Mag. June, 1843, p. 401; November, 1843, p. 742, and January, 1844, p. 28; or Meteorology of Thunder-storms, pages 9, 44, and 52.

Digitized by Google

of the *Scylla*, lightning, both sheet and forked, exploded near the ship without striking her at all. This has been observed in several other cases. For instance, H.M. Ship *Southampton*, 50, was, on the 30th June, 1842, exposed to a tropical thunder-storm. The master of the ship, Mr. Martin, states, that "it lasted from 10 P.M. to 2 A.M. the thunder and lightning being quite incessant. The lightning struck the sea close to the vessel, but no explosion occurred on the Conductors." A similar case occurred in H.M. Ship *Sapphire*. See Report and Evidence, &c. p. 93. In ships also, without Conductors, we find lightning often striking upon the sea near them, as in the case of H.M. Ship *Arab*, 22. The log describes the electrical discharges as "thunderbolts flying about the ship, two or three of which fell into the water, within a cable's length of the ship." All this is of practical value, inasmuch as it clearly proves, that the conductors only operate in carrying away the lightning, when it falls on them; but they do not necessarily draw it down on the masts. We have seen how well they performed this duty in the *Scylla*, &c. When, however, the discharge fell on the masts of the *Arab*, in the case just alluded to, which at last it did, the spars were shivered in pieces, three men were killed, and six men wounded.*

Upon the whole evidence, therefore, there cannot be the least doubt of the electrical discharge, in its most severe form, having fallen on the ships in the way described, and of their having escaped the damage usually attendant on it; and it is also evident, that the electrical agency was deprived of its explosive action, from the instant of its reception by the conductor aloft: from that instant, it existed no longer under the form of lightning. Its terrible expansive force, its sulphureous and suffocating odour, its inflammatory effect on combustible bodies, so commonly experienced in ordinary cases, are here unknown;† and it may hence be fairly inferred, that by means of the system of electrical conduction carried out in these ships, the British Navy, and shipping generally, may be effectually secured against the ravages of one of the most destructive and fearful elements of nature.

On a comparison of these few cases of protection, with the numerous instances in which damage has occurred, the amount saved by the Conductors would not be far short of 10,000*l.* to say nothing of more vital considerations. This may be easily shown in estimating the destructive effects which might have ensued, by those which have actually resulted under

* Naut. Mag. June, 1843, p. 394; or Meteorology of Thunder-storms, p. 2.
† See case of the *Rodney*, Naut. Mag. for October, 1844, p. 666.

Digitized by Google

similar meteorological circumstances. Thus the case of the *Scylla* may be compared with the case of the *Arab* as above shown; the case of the *Asia*, 84, is parallel with the case of the *Rodney*, 90; the circumstances of the storm, winds, &c. being nearly alike, and so of the others. Now the cost of refit of these ships is known: the refit of the *Rodney*, for example, at Malta, including a new main-mast, must have amounted to a considerable sum, certainly not much less than 2,000*l.*, without taking into account the detention of the ship, and the loss of her services for six weeks.

The reader is referred to the pages of the Nautical Magazine from June, 1843, to June, 1844, for a history of damage by lightning to the British Navy, as taken from the Official Journals of the ships; as also to a collection of these papers, termed "Meteorology of Thunder-storms."

The cases of the *Surinam*, 18, *Trident*, 64, *Clorinde*, 44, *Eagle*, 74, *Lowestoffe*, 36, *Thisbe*, 36, *Theseus*, 74, and some others, furnish very marked illustrations of the dreadful havoc produced by lightning, in forcing its way through bad conducting matter.

In the case of the *Surinam*, the main-mast was shivered, and in its fall stove in the deck, and destroyed the cabins beneath; signals of distress were made, and the ship was nearly lost on the French coast. In the case of the *Trident*, the electrical discharge is said to have burst forth from a dense black cloud right over the ship, as in the instance of the *Scylla*; it shivered the spars of the main-mast, filled the ship with smoke, and with a suffocating smell of brimstone, severely burned four men, and so disabled the ship that she was taken in tow by one of the squadron, for two days. The *Thisbe* and *Lowestoffe*, were left mere wrecks on the sea; the *Eagle*, 74, was in danger of being burned; and these instances may be taken as mere samples of the mass of damage recorded in all the other cases.

In conclusion, it may be worth while to observe, that the electrical agency, whatever it be, only assumes the conditions of what is commonly termed Thunder and Lightning, when it is determined in its course through bad conducting matter, such as air. In pursuing its course through bodies which offer comparatively little resistance, such as the metals, it becomes robbed, as it were, of its explosive power, and exists no longer under the form of lightning; the great body of the discharge is reduced, in fact, to the condition of a comparatively quiescent current, and little luminous effect attends it, except an evanescent electrical light, of a perfectly harmless character, induced in the air immediately contiguous to the surface of

Digitized by Google

the Conductor. The common notion that lightning is attracted towards, and brought into a ship, by conducting bodies, will be seen by these cases, to be quite unfounded: where the Conductor is perfectly continuous and capacious, from the highest points to the sea, the explosive action constituting lightning, vanishes from the instant the electrical agency strikes on the head of the mast. Instead therefore of lightning being drawn down into the body of the vessel, and deposited there, as many have erroneously supposed, it is virtually prevented from coming into the ship at all.

LXII. *Peltier's Views of Atmospheric Electricity.* Note by M. MARTINS. From Kaemtz's Meteorology.

(TRANSLATION.)

As M. Peltier deduces from his experiments and observations interpretations very different from those of other philosophers, we deem it useful to present here the summary of the researches that he has published up to the present time, and those which he has recently communicated to us.

An old experiment of De Saussure and Ermann, which remained without any result, is the starting point of the series of facts which induce him to regard the aqueous and igneous phenomena of the atmosphere in an entirely new point of view. The following is this fundamental experiment, as it has been modified by M. Peltier.*

A person stands on a perfectly open place, above all the surrounding objects: he takes an electrometer, armed with a rod of about four decimetres in length, surmounted by a ball of polished metal of from three to four centimetres of radius, in order to increase the effects of induction, and to avoid the escape of the electricity which may be repelled in the upper part. The instrument is held in one hand and adjusted with the other, by putting the rod in connection with the platinum. All the reactions being equal on all sides, the gold leaves of the electrometer fall straight, and mark zero. In this state of equilibrium the instrument may be left in contact with the free air for a whole day, under a clear sky, without its manifesting the least signs of electricity: we may even

* *Vide* his Memoirs in the *Annales de Chimie et de Physique*, t. iv. 3d series; *Memoires de l'Acad. de Bruxelles*, t. xv. 2d part; his *Traité des Trombes*; the article *Atmosphère* of the Supplement to the *Dictionnaire des Sciences Naturelles*; and the *Comptes rendus de l'Acad. des Sciences* of Paris, from 1838 to 1842.

Digitized by Google

move it and agitate the air; from the instant it is held at the same height, it will remain entirely still. But if, instead of leaving it in the same stratum of air, we raise it from four to five decimetres, we immediately see the gold leaves diverge and indicate a *vitreous* tension. (M. Peltier prefers the words *vitreous* and *resinous* to *positive* and *negative*, as being less significant and not savouring of any theory.) If we restore the instrument to the original place, the leaves fall again exactly to zero; if we cause it to descend below this point of equilibrium, the leaves diverge again, but then they are charged with *resinous* electricity. On raising it again to the original point, the instrument recovers its zero, and preserves nothing of the free electricities which it showed an instant before. Since no free electricity remains in the instrument, the air, therefore, has not communicated anything to it, and the signs which it gave were only the result of a new distribution in the electricity, which the rod possessed at the point of equilibrium; we have merely to replace the instrument at the same point to make them disappear. They were, in short, only signs of induced electricity in a body which approaches or recedes from another charged with free electricity—a phenomenon which may be reproduced in a room by standing on a *resinous* or under a *vitreous* surface.

If, instead of a polished ball, we place one or several points, or a lighted match, as Volta did, the phenomenon ceases to be simple, and no longer permits us to distinguish whether the primitive effect was a new distribution of electricity, or whether it is electricity taken from the atmosphere. In fact, when we raise the instrument, the *resinous* electricity coerced by the *vitreous* induction of celestial space to the extremity of the rod, instead of maintaining itself there, escapes by the points or by the flame; when we lower the instrument it is deficient of all the dispersed electricity, and the former equilibrium cannot be re-established. Then there remains permanent *vitreous* electricity, which is wrongly attributed to the contact of the air; it is in reality only the portion separated from that of the contrary name which has vanished by the points, and which can no longer be neutralised when we replace the instrument at the original point.

This experiment, proving that neither the air, nor the vapour that it contains, possesses free *vitreous* electricity, invalidated the consequences that Volta, Lavoisier, and Laplace had drawn from their experiments. On repeating and analysing these latter, *M. Peltier has endeavoured to prove that vapour

* Researches on the Cause of the Electric Phenomena of the Atmosphere, *Annales de Chimie et de Physique*, t. 4, 3d series.

Digitized by Google

produced at a temperature below 110° centigrade (230° F.) never carries off free electricity; that there is no electricity but that formed at a temperature higher than 110°. This temperature not being that of the surface of the globe, the electric vapours which rise cannot, therefore, proceed from the simple evaporation of saline or pure waters.

The electricity of clouds and fogs cannot be denied: he inquired whence it proceeded. As soon as he had established that the terrestrial globe is a body charged with *resinous* electricity, it was easy to demonstrate, by experiment, that the vapour which rises is *resinous* like itself, that this electric state of the globe is a powerful cause of evaporation, and that this latter may be quintupled and sextupled by a high tension. The vapour which rises from the earth being *resinous* like itself, its tension must react downwards against that of the globe, and successively reduce all its effects. This is what takes place; and it demonstrates the decrease of terrestrial induction on the electrometers in proportion as vapour is formed during the heat of the day. These instruments do not give the measure of the whole of the electricity, but only the difference of the quantities which act upon the coatings on the one hand, and upon the rod that sustains the gold leaves on the other. It follows that they may be placed in the centre of a mass of vapours, charged with a great quantity of electricity, without giving the least sign of it. Thus, their decreasing manifestation with the formation of vapours is a proof that these latter are charged with *resinous* electricity like the globe, and that they react from above downwards against this action, which is from below upwards.

Vapour being in a trifling degree conducteous, does not long retain the equal distribution of its *resinous* tension; the incessant action of the globe repels the *resinous* electricity towards the upper strata, and thus renders the lower strata *vitreous*. The new distribution of electricity is made the more easily in proportion as the density increases. This is why the electrometer, which had almost ceased to give electric signs in the middle of the day, gradually recovers extent in its indications when the condensation of the evening is felt: the lower vapours become *vitreous* by induction, and the upper vapours become more *resinous*. During the night, the lower vapours being deposited in dew, the quantity of the *vitreous* vapours has diminished, the upper vapours then react more freely, and towards the morning, the electrometer gives a less amount of indication than it did on the previous evening.

The first effect of the rising sun is to cause the vapours that are condensed during the night, to return into the state

Digitized by Google

of elastic vapour, whether they are or are not in the vesicular state.

These vapours being placed between the *resinous* earth and the *vitreous* celestial space, the first, that pass into the state of elastic fluid, carry off, on rising, a higher *resinous* tension, which they obtain by weakening such of the vapours as they leave behind, and which, having thus become less *resinous* than the globe, are *vitreous* in comparison to it and our instruments. During this first moment of the re-evaporation of the upper vapours, the strata left behind having become *vitreous*, are attracted by the earth, act more on our instruments by their proximity, and often produce a second dew, until at length the sun, by darting direct rays upon the earth itself, warms it and reproduces *resinous* vapours, which are diffused in the atmosphere, and re-act from above downwards on the instrument, as on the previous evening, and reduce anew the effect of the globe.

This play of electric induction is shown on a very grand scale, and several times a-day, around the tops of high mountains. Since M. Peltier has established that all grey and slate-coloured clouds are charged with *resinous* electricity, and that all the white, rose, or orange-coloured clouds are charged with *vitreous* electricity, it was easy for him to follow at a distance this order of phenomena, without being obliged to go and measure their tension with the electrometer. This is the extract of his observations. When a white cloud hangs over the summit of a mountain, its powerful *vitreous* tension rouses and hastens the evaporation of its damp sides; the quantity of vapours produced get beyond the point of saturation of these cold regions, they immediately pass into the state of vesicular vapour, and appear under the form of ashy-grey flakes, of a tint which is deeper as the upper cloud is of a more dazzling white. The grey tint does not long remain uniformly distributed; the *vitreous* attraction of the white cloud renders the bordering of the grey cloud more *resinous*, which then takes a deeper tint and forms a narrow riband at its upper part. This extreme stratum is divided into sinuous and trembling striæ, which shake, rise, and disappear, by passing again into the state of elastic vapour. These first vapours being dispersed, are replaced by others, which experience the same transformation, and so on. The greatest *resinons* tension of the upper riband, as manifested by its more slate-coloured tint, cannot take place but by taking from the former vapours the *resinous* electricity which they have carried off from the earth; by the decrease of their *resinous* tension, these latter lose by degrees their grey

Digitized by Google

tint, and finally become almost as white as the upper cloud. This last itself has lost its original lustre, in proportion as its own vapours were neutralized by those which radiated from the grey band. The phenomenon then stops, and the mountain ceases to *smoke*, not to commence again until the winds shall have cleared it from those clouds which have become similar.

The presence of a grey cloud above the summit of the mountain produces an analogous effect, but with inverse electric signs. The cloud which issues from its sides is white; it is charged with *vitreous* electricity; its upper riband is more dazzling than the centre; it repasses into the state of electric fluid, and the rest loses by degrees its lustre and becomes grey. In fact, these same phenomena are again produced under a clear sky, but with less energy; the *vitreous* tension of celestial space is sufficient to carry the evaporation beyond the point of saturation of that stratum of air. The electrometer also frequently indicates that the invisible elastic vapour is powerfully charged with electricity, which is sometimes *vitreous*, at other times *resinous*. Under this new influence, the smoking of the mountains considerably increases; this abundance of vapours proceeding from the side of mountains is itself an indication of the presence of upper vapours, still in a transparent state. It also shows that their near condensation, in proportion as their electricity is neutralised, will give abundant rains.

On attentively following all these transformations on the mountains or in the middle of plains, we see that every day produces very nearly the same series of facts. There are vapours produced either by temperature alone, or by temperature seconded by electric attraction; then towards evening, or during the night, their condensation takes place, and, consequently, a new distribution of electricity under the influence of the globe. At sunrise, it is the re-evaporation of opaque vapours, or a fresh dilatation of those which are yet elastic; both are produced under this same influence, *resinous* below, *vitreous* above: the first vapours that rise are the most *resinous*, the last are less so, and are then *vitreous* in comparison to the first; they thus form opaque clouds of different tensions, when cooling condenses them. The daily vapours, by thus rising in the atmosphere, soon experience the effect of another electric induction, which powerfully reacts from above downwards: it is that of the upper current of the atmosphere, which carries away to the polar regions the *resinous* vapours of the tropical regions. The height of this current and the energy of its *resinous* tension varying with the seasons, pro-

Digitized by Google

duce reactions more or less distant from the surface of the earth. There is, again, between these two forces a resultant of the difference depending on the proximity of one or other of these forces, and the concomitant actions of temperature and winds. We cannot enter into further details,—it would be trespassing beyond the limits of a note; it is enough to have pointed out the new path that M. Peltier has followed in his works; each one will be able to obtain evidence for or against these results by new observations, and thus to decide, by the aid of time, which is the road that conducts most directly to the knowledge of the true cause of the meteors.

LXIII.—Resumé by M. PELTIER of his Memoir, *On the Nature of the Electricity of the Atmosphere.* From Bulletins de l'Académie Royale de Bruxelles. May 9th and 10th, 1842.—t. 9. No. 5, p. 416.

(TRANSLATION.)

1st.—PONDERABLE matter alone has the power of coercing the cause of electric phenomena; the phenomenon by which this coercitation is produced, is that which is improperly named *resinous electricity*, or still more improperly, *negative electricity*.

2nd.—As pure space, void of ponderable matter, does not coerce this cause in a special manner, it cannot react with equal force against a *resinous* action; this negation of *resinous* reaction is termed *vitreous electricity*, or more improperly still, *positive electricity*.

3rd.—The earth, as being a ponderable body, possesses a powerful *resinous* tendency; and as the celestial space, by which it is surrounded, does not possess this condition, it is in the *less-resinous*, or *vitreous* state.

4th.—The earth, like every other electric body, in the midst of a free space, possesses its tension on the surface; and this tension may increase or diminish in certain points of its surface, according as the bodies situated above it have a less or a greater tension; that is to say, according as these bodies are *vitreous* or *resinous* with respect to the electric mean of the globe.

5th. Every body situated on the surface of the earth shares in its *resinous* tension. The more it projects into space, the more does this tension increase; thus mountains, edifices, and even organized beings have greater degrees of *resinous* tension than the soil on which they rest.

Digitized by Google

6th.—When a body is insulated, after its having been placed in connection with the soil, it is in equilibrio of reaction in all its parts, and according to the distance of each of them; the lower portions are less *resinous*, the upper are more *resinous*. In this condition of distributive equilibrium, if this body possesses mobile parts, as the gold leaves of an electrometer, they will not indicate any preponderating action.

7th.—If, under a dry and serene sky, this body or electrometer is moved further from the surface of the ground, or from an elevated body connected with the ground, as the reaction of the globe no longer operates in the same proportions on the length of the insulated stem, the *resinous* electricity becomes differently distributed; it increases towards the upper part, it diminishes toward the lower, and the mobile leaves attached to the latter separate from each other, in order to approach bodies either connected with the ground or possessing the same tension with it. This *less-resinous* tension, which the gold leaves now possess, is termed *vitreous*.

8th.—If the electrometer is brought down again, the former equilibrium is restored, and the leaves rest at zero.

9th.—If it is brought down below the point of equilibrium, as the reaction of the globe increases more on the upper than on the lower part, its *resinous* electricity is proportionately repelled; it becomes dominant in the lower portion, and the leaves diverge *resinously*.

10th.—To deprive this experiment of all complication, the upper extremity of the electrometer must be terminated by a polished ball, so as to avoid radiation and to increase the effects of induction. In this condition, the electrometer may remain for twelve hours, exposed to the air and winds, without its manifesting the least electricity.

11th.—Since there is no electrical phenomenon without ponderable matter, radiation between two bodies differently electrized, occurs more favourably as these bodies or one of them evaporate more easily; consequently, water, on the surface of the globe, which possesses a powerful *resinous* tension, evaporates under this electric influence. These vapours carry off a *resinous* tension, equal to that of the surface of the liquid, and they are diffused in the atmosphere, according to their specific gravity, and their repulsion as bodies charged with the same electricity.

12th.—The vapours thus dispersed react from above downwards upon the electroscope; they place it within a *resinous* precinct; and the instrument, by rising or falling, experiences feeble differences of reactions, or even sometimes it undergoes no appreciable reactions: in the latter case, it is only by an

Digitized by Google

ascent with a kite or a balloon, that the extremity of the instrument can emerge from this precinct of homogeneous reactions. By taking as a starting point the influence obtained under a serene sky, and with a continued cold of at least six degrees below zero, (21°2 F.) the value of the diminution will be the measure of the quantity of *more-resinous* vapours, contained by the atmosphere.

13th.—Fixed apparatus of limited extent are useless in dry and serene weather; they can give no manifestation of induced electricity, because they remain in their place of equilibrium; and they have not sufficient power to radiate the electricity contained in their parts, because dry air is a good insulator. When they have considerable length and are very elevated, as the extent of the wire compensates for their feeble local radiation, the apparatus loses its induced electricity, and becomes charged with permanent electricity.

14th.—When the air is slightly moist, its radiation is favoured, and currents are obtained with shorter lengths.

15th.—These electrical phenomena, arising as they do from atmospheric influences, must not be confounded with those produced by the oxidation of conducting wires, when plunged into a moist medium. From this cause of error, it has frequently happened that effects, appertaining to chemical action, have been attributed to the atmosphere.

16th.—When, through a fall of temperature, the first vapours are condensed, they form opaque clouds, and the electricity that they have carried away, is distributed according to their groupings and their ambient influences. The influence of the earth renders these clouds more *resinous* in the upper part than in the lower; consequently, the electrometer will exhibit a greater divergence under these vapours compacted into clouds, than when they were disseminated in all directions.

17th.—When the temperature rises, and the primitive clouds pass again into the state of elastic vapour, it is under the *resinous* induction of the earth beneath, and under the *vitreous* induction above. The first vapours, which then rise, are more highly *resinous*, while the last are less so. The atmosphere then contains masses of *more-resinous* elastic vapours, and other masses of *less-resinous* or *vitreous* vapours. In a word, there are, under these circumstances, transparent clouds, some charged with *resinous*, others with *vitreous* electricity; and intermediate or neutral spaces, which are very clear. The limits of these transparent clouds may be discovered by means of the kite or balloon.

18th.—The condensation of these transparent clouds forms

Digitized by Google

secondary opaque clouds, charged with their respective electricities. A new rise of temperature produces a fresh division in the electric charges. The vapours first produced are more resinous than those which preceded them; the last are less so: they are *vitreous* in respect to the higher vapours, and *resinous* in respect to the lower. It is in consequence of these successive condensations and evaporations that the upper vapours acquire *resinous* tensions of increasing value, while those near the ground become more *vitreous.* Intermediate, there are some of different degrees, which are maintained separate by the difference of their specific gravity.

19th.—In proportion as the vapours, in consequence of these transformations, become charged with an increasing electricity, their molecules acquire a greater degree of mutual repulsion; they are more repelled from the earth, or attracted toward space; they rise to much greater heights than those which correspond to their specific gravity. These opaque or transparent clouds, being charged to different degrees with *resinous* electricity, some of which, in respect to the globe, which may be called normal, are *resinous,* and others *vitreous;* —these clouds, we say, are in mutual equilibrio, when they approach in consequence of the condensations which arise from reductions in the temperature, and the reduced terrestrial repulsion, when other strata of clouds are interposed. Changes then occur which vary with their mode of agglomeration and their conductibility. These exchanges produce sudden explosions, if the periphery of the clouds contains much free electricity, or else *protracted explosions,* if the conduction is feeble, and if the discharge takes place along the masses opposed to each other.

20th.—A discharge being a production of equilibrium in one point, excites other discharges; and thus it is that the meteors succeed each other, and may at certain periods become very numerous. Thus it is that simultaneous meteors, or those which succeed each other at short intervals, are observed in countries distant from each other.

21st.—Consequent on these productions of equilibrium, or electric discharges, as the vapours become less repelled, gravity regains its influence; they fall, they condense, and finally they are resolved into rain.

22nd.—Rains arising from *resinous* clouds are more abundant than those arising from *vitreous;* in like manner the winds are more sudden and more violent; and it is under the influence of masses of *resinous* clouds that tempests and inundations arise.—[A.]

Digitized by Google

LXIV.—*On the different species of Fogs.* By M. Ath. Peltier. Analysis by M. Quetelet. From Bul. de l'Acad. R. de Brux. Aug. 6th, 1842.—t. 9, Second Part, p. 148.

(TRANSLATION.)

M. Peltier, among modern philosophers, is the one who has entered with the greatest activity into the study of the electricity of the air. We owe to his persevering cares not only writings on electric phenomena of high interest, but also important improvements in the construction of the instruments, that are used for developing these phenomena, or for measuring them.

In a former memoir,* M. Peltier made known to you the result of his researches *on the cause of the electric phenomena of the atmosphere, and on the means of collecting their manifestation.* This paper, the importance of which you appreciated, has been since published in Vol. IV. of the *Annales de Chimie et de Physique.* The object of the new memoir, which he presented to you, at the meeting of July 2nd, is the study of the different species of fogs. We will endeavour, by a rapid analysis, to give an idea of the ingenious views of the author on this kind of phenomena, the study of which leaves so much to be desired.

According to De Luc, B. Davy, and G. Hervey, a fall of temperature to the amount of about two or three degrees below that of the surface of the waters, or of the moist ground, is sufficient for the production of fog; and the fog is thicker, in proportion as this difference between the temperature of the air and that of the waters is greater. This theory possesses the greatest simplicity; but it is insufficient to explain the existence of a great number of fogs; and, as M. Peltier observed, it is necessarily complicated by the effect of electric actions and re-actions. The first cause of this complexity is the formation of vapours at the surface of a body charged with resinous electricity,—vapours which consequently participate in this state, and are also resinous. The second cause is in the re-action of the resinous vapours of the vast current, that is constantly advancing from the tropics toward the poles, in the high regions of the atmosphere.

From these different influences, there result, according to the author, three sorts of fogs, which are divided into five very distinct species: the first is that of simple fogs; the second and third are those of resinous fogs; the fourth and fifth are those of vitreous fogs.

* Vide preceding Article.—Ed. Elec. Mag.

Digitized by Google

Simple fogs are the product of the condensation of elastic vapours by the cooling of the air, when the latter has fallen several degrees below the temperature of the ground on which it rests; they are always moist, and they moisten the cold bodies that they touch. These fogs appear toward the end of a fine day; they rise slowly into the atmosphere, and remain at a very low elevation. They are of a dead white, and diminish the light without colouring it; and their surface is smooth and tranquil.

It would seem that *resinous fogs* should be the more numerous, because as the terrestrial globe is a body charged with resinous electricity, the vapours that rise from it are resinous like itself. This species, however, is not common; the cause of transformation in the signs of the electricity is in the very law itself of electrical inductions. The earth repels the resinous electricity toward the higher strata, and thus renders the stratum that is nearest to the ground, vitreous. In order that such a fog may remain in contact with the surface of the globe, it is necessary that another power should have a preponderance over the repulsion of the earth, or that this terrestrial repulsion should be reduced by a similar force acting in the contrary direction. The former effect is produced by the specific gravity which clouds sometimes acquire; and the latter, by the repulsive power of the highly resinous upper strata. Resinous fogs, produced by these two causes, are distinguished by particular qualities, which divide them into two different species.

Vitreous fogs are also of two species, which present very distinct results. The first is that, which occurs under a serene sky, without any other electric influence than that of the globe. This species has its lower portions more vitreous than the upper, and they are powerfully attracted by the globe. The other species is that which is formed under the influence of the masses of highly resinous vapours, which prevail in the upper strata. This latter has its upper portions more vitreous than the lower.

We conceive that we need but briefly to point out the distinction between the five species of fogs recognized by M. Peltier; we must refer to the memoir itself for all that concerns their special character, which are so well established that the mind may seize on them without difficulty. The author has given various examples in support of his theory; and he cites several from the annals of meteorology. —[A.]

Note.—The memoir, of which the above is an analysis, was ordered to be printed in the *Memoires couronnées par l'Acad. de Bruxelles.*

Digitized by Google

LXV. *Remarks on M. Peltier's Memoir on Fogs.* By M. Crahay. From Bul. de l'Acad. R. de Brux., Aug. 6, 1842; t. 9, Second Part, p. 152.

(TRANSLATION.)

The explanation of fogs, in many cases, presents difficulties which arise on the one hand, from the imperfection of our knowledge of the different states that vapours may assume, and on their manner of existence in their mixture with the air of the atmosphere; on the other hand, on the few known facts relative to the modifications of the atmosphere, which affect vapours suspended in it. M. Peltier was the first, so far as I am aware, who has included electrical forces; his idea is happy, and it cannot fail to lead him to important applications to the portion of meteorology which concerns the vesicular vapours of the atmosphere. The object of the memoir, addressed to the Academy by this learned philosophers and which I was called to examine conjointly with MM. Quetelet and Plateau, is to show how, by the play of electric actions, we may explain the phenomena presented by that species of vapours, in which, when considered in a mass, the name of *fogs* is applied.

This work, which I have read with the greatest interest, presents some very ingenious views; yet I cannot but confess that it contains others to which I cannot adhere. I shall take the liberty of consigning to the present pages a few of the reflections suggested to me by reading it. The theory of fogs put forth by the author, lays down as a fundamental principle the opinion which he developed in a previous memoir; and, according to which the terrestrial globe possesses a powerful resinous tension, peculiar to itself, whilst the celestial space surrounding the atmosphere, being deprived of real electric fluid, owes to this negation an electric reaction, which, according to the author, is named vitreous electricity. From this hypothesis, he explains the different manners in which electroscopes conduct themselves under a dry and serene sky; an hypothesis, which is not entirely free from objection.

In his theory of fogs he assigns an important part to the vast current, which, in the high regions of the atmosphere, is passing from the tropics toward the poles, in order to compensate the lower current, the direction of which is opposite to the preceding, and which constitutes the trade-winds. The vapours, carried along by this upper current, are said to

Digitized by Google

be always resinous; and, consequently, would communicate their tension to the high regions of the atmosphere. Now this current, which must be as constant as the trade-winds themselves, and which, consequently, like them, experiences only a slight change in direction, dependent on the seasons, would, therefore, constantly communicate resinous electricity to the higher strata, which ought to intercept the entire action of vitreous space by the substitution of its own. According to this, the explanations of the phenomena presented by electroscopes, as given by M. Peltier, in his Memoir on the Electricity of the Atmosphere,—explanations founded on the existence either of the simple resinous electricity of the earth, or, concurrently with this of the vitreous electricity of upper space, would experience notable modifications. Moreover, in regard to the constancy of the tropical current, on account of the great height at which this current prevails, its resinous state cannot be altered by the modifications that take place in the less elevated regions of the atmosphere. Hence it follows, that the action of this current cannot give rise to the daily changes in the circumstances which at one time cause its influence to surpass that of the earth, or of the resinous vapours arising from it, and at another time cause the latter to exercise a preponderating action; changes which we must admit with the author, in order to explain the sometimes sudden variations in the state of fogs. We must not forget, that the resinous tension of the tropical current is a supposition laid down by the author.

In § 7, the author speaks of a mass of vapours descending toward the surface of the ground by an increase in the density of the vapours, and which, in his opinion, *is merely a resinous cloud, descending by its gravity, and not a fog properly so called.* I do not understand this distinction: it is well established, that the state of the vapours in clouds is the same as that in fogs; that the only essential difference is in their relative distance from the earth.

Further on, in the same paragraph, he says that *these resinous clouds, being rather repelled than attracted by terrestrial (resinous) bodies, skim over these bodies without wetting them.* Now this peculiarity of not wetting bodies may be also due to another cause, namely, because the temperature of the bodies is not lower than that of the fogs; and that the space, in which the latter are suspended, is not supersaturated. In like manner, *the moderate influence exercised on the hygrometer by the abundant rain into which these clouds are often resolved,* may arise, not from an electric repulsion exercised by the hygrometer upon the vapour produced by the rain, but

Digitized by Google

because the stratum, in which the instrument is placed, is far from the point of saturation, whilst that in which the cloud occurs is supersaturated, in consequence of a great fall of temperature that it has undergone. The cooling of the upper strata in which a cloud is resolved into rain, is well indicated by the fall of the thermometer when exposed to this water at the moment of its fall.

In the classification, established by the author in his memoir, he recognizes *invisible fogs*, both resinous and vitreous, which exist under a pure and serene sky, and the presence of which is only manifested by their action on electrical apparatus. I ask in what this state of the atmosphere differs from its habitual state, when there is no fog at all, and when, however, it contains a notable quantity of the vapour of water.

In § 9, in order to explain the manner in which certain resinous fogs conduct themselves, the author calls to his aid an experiment, in which, when particles of elder pith, insulated by silk threads and electrized, are placed between two conductors charged with the electricity of a contrary nature to that of the particles, the latter approach each other more closely; and, on the contrary, these particles would be mutually repulsive if the conductors had electricities of the same nature as that of the particles. These phenomena, according to the author, would be brought about, because the respective induction of the particles *would be attenuated, and their mutual repulsion diminished*, in presence of a body charged with a fluid of a dissimilar nature; on the contrary, their reciprocal repulsion would be augmented if this foreign body were charged with a similar fluid to that of the particles. In attempting this experiment I could not succeed in producing the effects in the order indicated by the author; nor could I find, in the re-action of electrized bodies, any reason why it should be so.

I do not understand how a cloud, which possesses free electricity on its periphery, can suddenly attract air, and then repel it, and produce by this puffs or gusts of wind. (§ 18.) The case, in my opinion, is altogether different from that of light bodies; towards which, in our experiments, we bring an electrized conductor.

In § 20, the subject is the induction of the vitreous space in the higher regions with a pure and serene sky. What has become of the tropical current with the resinous tension? For what reason does it not exist now?

In spring and autumn we sometimes observe very thick fogs, which appear toward evening, which have a bluish colour, that

Digitized by Google

colours the sun with an intense red, and which moreover are characterized by a strong odour of peat, or burned lignite; an odour with which our apartments often remain impregnated the next day, after the fog itself has disappeared. These, which are called dry fogs, because they do not affect hygrometic bodies, are, I fancy, what the author describes in §§ 23—25. Between these and ordinary moist fogs he sees no other difference than that, under circumstances in which dry fogs are manifested, the surface of the earth would have vitreous electricity, like the fog; and, consequently, the latter, being repelled by terrestrial bodies, would be prevented from depositing on them and moistening them. I cannot possibly share in this opinion. All the circumstances, that accompany the appearance of this species of fog, lead to the presumption that it is not like an ordinary fog, formed of the vapour of water in a vesicular state, but that its composition is different; consequently, that it owes its origin to causes quite different from those which give rise to the aqueous vapours of the atmosphere. Perhaps it is due to the burning of peat, which is carried on over very great extents in the northern countries of Europe, at the two seasons of the year when the fog is manifested.

After having taken up the points on which I do not share in the opinion of the author, or on which I am not sufficiently enlightened, I will not terminate this report without repeating, that for many phenomena the work contains very plausible explanations; and that I have no doubt, that in such skilful hands as those of the author, the theory of fogs will make great progress by the application of electric forces. The memoir, moreover, evinces the vast knowledge which the author had previously shown in his anterior productions. It will be read with profit by all those who are interested in meteorology; I, therefore, vote that it be inserted in one of the publications of the Academy.—[A.]

LXVI. *Reply of* M. PELTIER *to M. Crahay's Remarks on his Theory of Fogs.* From Bul. de l'Acad. R. de Bruxelles. Dec. 3, 1842; t. IX., Second Part, p. 496.

(TRANSLATION.)

M. CRAHAY, having in his report expressed doubts on certain parts of this work, permit me to enter into a few explanations, because, through my own fault, I have not been sufficiently understood. Meteorological phenomena are so in-

Digitized by Google

timately linked together, that it is a very difficult task to treat of one, without having need of the concurrence of others. This binding together of the meteors is a disadvantage to the demonstration of phenomena, which we desire to study separately.

The first of M. Crahay's doubts concerns the electric state of the lower atmosphere, under the influence of the tropical current, carrying along vapours charged with resinous electricity, and under that of the globe possessing a tension of the same nature. Although this subject is reserved for another work, I ask your permission to anticipate the presentation, by a few words, which may remove the doubts of your learned colleague.

I have been careful, in all my works on electricity, to insist on a fact which has been long disregarded; it is that our instruments only indicate *differences*, and not *absolute quantities;* that the signs, which we have termed *positive, negative, vitreous, resinous,* are signs exactly of the same order; and that their value depends on the point of equilibrium, from which we set out. With respect to ourselves, who are placed on the terrestrial globe, the degree of its electric tension forms our equilibrium, according to the distance at which we hold our instruments. After having reduced an electrometer to a state of equilibrium, if we remove it further from the surface of the earth, the resinous induction of this latter on the polished ball of the upper extremity diminishes, it retains there a less amount of vitreous electricity; and the portion rendered free is distributed over the whole insulated system, of which the gold leaves form a part. It is not the air discharging its electricity on the ball, for neither time, nor wind, nor the agitation of the instrument from one side to another makes it acquire permanent electricity; the gold leaves always fall to zero when the electrometer is replaced at the starting point. It is quite otherwise, if we make the experiment in the midst of vapours strongly vitreous, as are white fogs. Scarcely is the instrument exposed to contact with these, than it is charged with a permanent vitreous electricity, without its having been removed from the place of its equilibration. The fog acts as would an electric atmosphere of itself.

But how comes it that the atmosphere plays the part of a *vitreous* body, since the portion that surrounds us is surmounted by the tropical current, charged with the same electricity? The answer is found in what has just been said: it is the different degrees of the induction of those bodies, which render bodies interposed in this space either vitreous

Digitized by Google

or resinous to us. An experiment, which I had reserved for another work, will throw light upon this question.

Two large insulated globes, charged with the same electricity, are placed two or three yards apart. In order to inquire after their respective influence in the space which separates them, we take an electrometer furnished with a rod 5 decim. (19½ in.) long, terminated by a ball 5 or 6 cent. (2 in.) in diameter. This rod, instead of being vertical, is screwed in at right angles, in order that the principal induction may be obtained on a given point. On passing this ball into the intermediate space,* the leaves are seen to open, to close, and to open again, and give signs of contrary electrary electricities, according to the point of the space to which the ball is conveyed, and that, in which the equilibrium of the instrument was restored. Near the globes the vitreous electricity is attracted, and the surrounding atmosphere plays the part of a *vitreous* body, whilst bodies placed in the middle of the space are in a resinous tension with respect to those which are near the globes. These different tensions may be measured, by placing between these globes an insulated metal rod communicating with three electrometers; the extreme balls are vitreous, and that at the middle is resinous. This distribution exists in the atmosphere.

Observation and experiment having demonstrated to me a constant relation between the colour of clouds and their electric tension, we may recognize the electrical condition of clouds, however great their distance may be. Elevated clouds, those nearest to the tropical current, are white and fleecy, or *cumuli* whiter still; these clouds are then charged with vitreous electricity, according to my observations, which can leave no doubt for any one who would verify them. Below this stratum, in the intermediate zone are foaming, grey, slate-coloured strata, indicated by their hue, and they are charged with *resinous* electricity.

Finally, the lower vapours, whether transparent, or opaque, in the condition of white fog, are charged with vitreous electricity, as indicated by the electrometers. This is the normal condition of the atmosphere, in very variable degrees, according to the weather, the temperature, and the seasons; we can only give a glance at this subject in a letter. We must also postpone to a more extensive work the proofs of the tropical current, and of its powerful *resinous* tension.

* While the ball is passing in a straight line along the distance which separates the two large insulated globes, the horizontal rod, on which it is supported, and which is attached to the electrometer, remains perpendicular to this some distance.

Digitized by Google

These proofs are quite as abundant as those by which the electric tension of the globe has been demonstrated.

I cannot reply to all M. Crahay's doubts, without touching, as may be seen, on all points of meteorology. In the impossibility of doing this in a letter, I beg this philosopher to suspend his judgment until my other researches are presented. Meanwhile, although this letter is already very long, I cannot terminate it without expressing the astonishment I have experienced, in learning that he had not succeeded in the experiment of the cloud of pith balls. I think M. Crahay must have forgotten to electrize the pith balls, for their repulsion by the same electricity, like their attraction by the contrary electricity, is the fundamental law of electroscopics. My cloud of pith balls is an electroscope, with a hundred instead of with two balls. They all repel each other, and form a larger volume when I bring near to them a body charged with the same electricity as that which has been given to them; and they all approach and form a less volume when a body charged with the other electricity is brought near. In order to electrize all the balls at once, a metal disc is raised by an insulating handle; and, when all the balls are resting on it, the disc is touched with the knob of a Leyden jar. The disc is then removed, and the play of repulsion or attraction is manifested according to the body, which is brought near.—[A.]

LXVII. *Note on certain Electric Phenomena,* presented by M. Crahay, *in Reply to a Letter by M. Peltier.** From Bul. de l'Acad. R. de Bruxelles, Jan. 7, 1843; t. X. No. 1, p. 19.

(translation.)

In my *Report on the Memoir of M. A. R. Peltier,* entitled, *On the different Species of Fogs,* I directed attention to certain points, on which I was not sufficiently enlightened, and others respecting which I could not share in the opinion of the author. The latter, in a letter communicated at the last sitting of the Academy, adds several new explanations in support of his memoir; and he defers to a more extensive work, which he proposes publishing, the proofs and demonstration of other points that are in discussion. I will wait for this new production before forming my opinion; but I cannot forbear, at the present moment, noticing a passage in the letter al-

* Vide preceding article.—Ed. Page 418 of present No. Elec. Mag.

Digitized by Google

luded to, in which M. Peltier replies to the objection that I made to an experiment quoted in his memoir. I will transcribe here the part of my report which refers to this point.

" In § 9, in order to explain," &c. [Our readers will find the passage quoted, by turning back to p. 420; it goes on to, " why it should be so."]

The following is M. Peltier's answer:—" I cannot terminate this letter," &c. [Vide p. 424 to the end.]

Assuredly I did not forget to electrize the pith balls; we cannot even conceive how the experiment could be attempted, if this had been neglected. I repeated the trial a great number of times with two, and with a great number of balls insulated by silk threads; and I constantly observed that, on presenting laterally to an electrized system a conductor charged with fluid of the same nature, the particles of pith did not separate any further from each other; neither did I observe that they approached each other, when this conductor was charged with fluid of the opposite nature to that of the globules. Nor ought this to be the case. We are not now considering the fundamental law of *electroscopics, in obedience to which a body is repelled or attracted by another, according as the latter possesses electricity, of the same or of a different nature to that of the first body.* This law does not fail in the present experiment, for the mass of the globules recedes from or approaches the conductor presented to it, according to the nature of its fluid; but we are considering *an increase in the mutual repulsion of the globules, if the neighbouring conductor is charged with the same fluid, or a diminution in this mutual repulsion, if the fluid of the neighbouring conductor were of the contrary kind to that of the globules;* an increase or a diminution, which would be brought about, according to the author of the memoir, because *the respective induction of the particles would be attenuated, and their mutual repulsion increased, or diminished, in the presence of a body, charged with fluid of the same or of a dissimilar nature.* Now, in the experiment in question, I was unable to observe either this increase or this diminution in the mutual repulsion of the globules; and, on this account, I said in my report, that I saw no reason for it in the theory of the re-action of electrized bodies.

Indeed, if two neighbouring globules, equally electrized, and situated on the line drawn towards the centre of the action of the conductor, charged, I will suppose, with the same fluid as the globules, the one which is nearer to the conductor is the more strongly repelled, and consequently approaches the other globule, instead of receding

Digitized by Google

from it, as ought to occur, according to M. Peltier. In like manner, if the conductor is charged with a fluid of a different nature from that of the globules, the nearer one will be the more strongly attracted; consequently, the globules must separate from each other, in the direction of the conductor, instead of approaching.

With regard to a dilatation, or a contraction, of the system of globules, in the direction perpendicular to the right line joining the centre of action of the conductor with that of the system of globules, it only takes place so long as the directions drawn from the centre of action of the conductor towards the lateral globules are very inclined in respect to the right line directed from the centre of the action of the conductor to that of the system of globules; and this is not the case with the cloud referred to in that memoir; for the cloud is placed between the surface of the earth and that of the equinoctial current—two surfaces, the extent of which is almost infinite, in respect to that of the cloud; and the electric actions of which, consequently, on each point of the latter, must be considered as parallel to each other. Thus M. Peltier's hundred-ball electroscope, which dilates and forms a larger volume, on the approach of a body charged with the same fluid, or contracts when a body charged with another electricity is brought near, if the globules are *equally charged*, cannot undergo any increase, except in a transverse direction, and then only when the conductor is of small extent, and very near.

In the preceding observations, I have supposed that all the globules were equally charged with electricity, which is very difficult to obtain, even by operating, as M. Peltier indicates in his letter; for the charges, which are at first equal, are not long in becoming unequal, in consequence of the difference of loss, experienced by the globules along the greater or less salient asperities of their surfaces, and of the different conductibility of the suspending threads. Moreover, the tendency of electricity to arrange itself on the surface, or the boundaries of conducting bodies, causes the globules on the circumference of the artificial cloud to obtain possession of a greater quantity of electricity than those placed toward the interiors. Now, when the charges are unequal, those of the globules that have the strongest charge are most repelled by the conductor possessing a similar fluid, and recede further than those which have less, in proportion as the conductor is brought nearer; a lengthening then takes place, in the direction of the line joining the centres of action. But it is easy to recognize the inequality in the charges of the globules; for

Digitized by Google

then those among them that are the most distant will always fly to the greatest distance from the conductor, when the latter is made to pass round the cloud of globules. The explanation will easily be applied to the case when the electricity of the globules is of a different nature from that of the conductors.

When, to a system of globules with charges as nearly equal as possible, large plates, possessing fluids of the same nature as the globules, are brought near at opposite sides, the mass of globules, being repelled in two opposite directions, compresses, and gains in width about as much as it has lost in length, so that the volume remains constant, if even it has not diminished. When the two plates possess electricities of a different nature from that of the globules, the cloud of the latter elongates in the direction of the attracting bodies, and contracts a little in the transverse direction. Thus in these cases, which are the analogues of the cloud, placed between the earth and the equinoctial current, we cannot say that the volume is sensibly changed; and, what is more, the most apparent effect occurs in a direction contrary to that which ought, according to M. Peltier, to happen.

I have found that, in these experiments, we may advantageously employ a bundle of simple silk threads unarmed with pith-balls. These threads, from fifteen to twenty centimetres long, are tied together at one end, whilst the other end is free; electricity is communicated to this bundle, by suspending it for a few moments to a conductor strongly charged; these threads then acquire charges, differing but little from each other, and they erect themselves into a tuft, which preserves the electricity for a long time. The tuft is suspended to a silk thread, while the effect produced on it by the approach of the conductors is being examined.

I have furthermore supposed, both in the experiments with the cloud of pith-balls, insulated by silk threads, and also with the tuft composed of simple silk threads, that the charged conductor was always approached *laterally*, and not from below upwards, beneath the artificial cloud; for, in the latter case, the result of the experiment is very different: we then observe a separation among the globules, or the threads of the tuft, if the electricity of the conductor is of the same kind as that of the globules or the threads; and a mutual approach, if the conductor is charged with a fluid of the opposite nature; but, in this mode of operating, the separation or the approximation is brought about by a cause dependent on the mode of the suspension of the globules or threads. Indeed, in the state of divergence, the direction of

Digitized by Google

the thread of suspension is that of the resultant of two forces, the one vertical, due to the weight of the globule or thread; the other horizontal, arising from the electric repulsion between the neighbouring globules. If even a very extensive conductor, charged with the same fluid as the globules, is presented from below, the repulsion from below upward, which the latter experience, diminishes the intensity of their vertical component; consequently, the resultant must approach the direction of the horizontal component: the globules must, therefore, separate further from each other; and it is easy to see that they must approach each other if the conductor presented below possesses a fluid of a contrary nature to that of the globules. But, once more, the mode of suspension of the pith globules has nothing in common with the manner, in which the vesicles of vapour constituting a cloud, exist in the atmosphere.

Such are the considerations upon which, in my report, I founded the passage relating to the experiment of the cloud of pith-balls; I can only refer to it.—[A.]

LXVIII.—*Atmospheric Electricity.* Reply of M. PELTIER to M. CRAHAY. From Bull. Ac. R. de Brux., t. X. No. 3. p. 201. March 4, 1843.

(TRANSLATION.)

M. CRAHAY's communication of the 7th of last January, has shown me, by the details it contains, the reasons why our results have not accorded. By using silk threads without any thing intermediate, and even by using silk threads in a skein, M. Crahay's experiments are perfectly exact, and the consequences he deduces from them are rigorous; I have no objection to offer against them. But my desire having been to imitate natural phenomena, it was my duty not to restrict myself to the usual methods, which took me too far away from my object; I was bound to take those, which brought me as near as possible to it. I had not given any details upon an experiment that belongs to another work, and the principal result of which,—the only one that is truly meteorological,—is to show the facility with which electricity is displaced in a system of corpuscules, more or less insulated, under the influence of a body charged with the same or with a contrary electricity. Moreover, one of these effects has been perfectly appreciated by M. Crahay, even when operating in the ordinary manner.

Digitized by Google

In order to approach as closely as possible to the natural phenomenon of the dissemination of vapours in the air, we ought to be able to place in the middle of this gas, small bodies of the same specific gravities as itself, without either supports or suspensions, in order to leave to them the opportunity of extending themselves in all directions, without experiencing any resistance. This power of keeping bodies thus suspended being denied to us, we must meet the difficulty and lessen it, and must so vary our experiments, as to obtain at several times that which exists simultaneously in the natural phenomenon.

Particles of vapour, being small bodies disseminated freely amid an insulating gas, the first obligation to fulfil is to make use of small, light spherules, without any conducting, or semi-conducting prolongation. This appendix would alter the result, by permitting a displacement of the electricity to the detriment of the spherule. In order to obtain this insulation, very small pith-balls are suspended to a glass stem covered with resin, by means of silk fibre, in order to have equal resistances; equalities which are not obtained with spun silk. The distance of the threads is so arranged as to have almost as many empty as filled spaces, in order to avoid the twisting of the threads, and to diminish the action of gravity, which would require to be overcome if all the threads arose from a single bundle.

Silk being an imperfect insulator, principally in moist weather and in moist situations, the spherules must be kept quite separate from it, by means of the slightest possible filament of gum-lac; and the experiment must be made a short time after the preparation, in order to opêrate before dust and moisture have deposited a conducting film upon the two filaments. These precautions, all insufficient as they however are, nevertheless prevent too rapid an escape, like that which happens with the silk fibre. The latter also exercises another action: when an electrized body is brought near it in a lateral direction, it is attracted, whilst the spherule charged with the same electricity as the body is repelled. It thus forms a convex line toward the body, which is an indication of its resistance, and of the obstacle it opposes to the repulsion of the pith-ball.

In order to electrize all the balls at once, a disc of metal is raised by means of an insulating handle, until all the spherules rest upon it; this disc is then touched with the knob of a Leyden jar, and they are thus instantaneously charged. In order to charge these spherules with the same intensity, we must take a metal disc that is not much larger in diameter

Digitized by Google

than the entire group; for, if it has a very large diameter, they will acquire a tension differing but little from that of the plane surface of the centre of the disc, whilst with a small plate, slightly convex, they become more equally charged, and acquire the tension of the salient parts.

These spherules, being thus charged with the same electricity, repel each other and form a more considerable volume than that of the neutral state. The more powerful the tension that has been given to them is, the greater is the interspherical separation, and the more is the total volume developed. We have merely, therefore, to take away from, or to add electricity to this representation of a cloud in order to diminish or to increase its volume.

Perfect insulation does not exist, and it diminishes the faster, the more we approach the ground, either by the influence of neighbouring bodies, which radiate a contrary electricity, or by the greater humidity of the air. It follows that the equal reactions of the interior of this cloud make the central spherules lose a part of their tension in favour of the exterior balls, which do not undergo a uniform reaction in all their surface. This radiation from the interior to the exterior, furnishes at the periphery a greater electrical sphere than would occur by the medium of a perfectly insulating gas, which would maintain around each spherule all its primitive electricity. This march of the electricity is much accelerated, if an electrized body is placed on one of its sides. If it is charged with the same electricity, that of the neighbouring balls being strongly repelled, they lose it rapidly in favour of the balls placed in the direction of the repulsion; and those at the extremity of the group in this direction acquire the greatest quantity. In consequence of this repulsion of that portion of electricity from the exterior toward the interior, the interspherical repulsion increases, as well as the separation of the balls. If the neighbouring body is charged with another electricity, we can see that the phenomenon will march in the opposite direction.

In natural phenomena, these changes exist at every moment, and principally in opaque clouds, where conduction is greatest. It is these incessant displacements of electricity by the reciprocal induction of the particles of vapour and by that of the neighbouring bodies, that we have wished to prove by this experiment; and we shall further see, as we have already indicated in our memoir on the electricity of the atmosphere, that the successive discharges of storm clouds are due to this instability of electric distribution.

The suspension of the spherules being always vertical, the

Digitized by Google

relation of the position of these bodies can change in the horizontal direction alone. The change that is brought about is not even the product of the single force that we are desiring to study, but of its resultant with that of gravity; this resultant, therefore, will vary according to the direction and the power of the electricity of the neighbouring body.

When we bring towards the side of the group, a body charged with an electricity similar to its own, the entire group is repelled, and its interior repulsion is increased in the manner we have just described. The increase of repulsion varies according to the place occupied by the spherules, and according to the duration of the electric induction. At the first moment, the new recession is about equal throughout the group; but it soon ceases for the spherules that are nearest to this body, and increases for those which are most distant. If we then examine the electric tension of these balls, by taking away from the group the balls that are nearest to the electrized body, and those that are most distant, on placing them in contact with an electrometer, we find that the former have lost all the electricity which had been given to them, and that the latter have acquired it,—that there has been a radiation, or electric transport of the former to the latter, under the repulsive influence of the neighbouring body.

If the suspending fibre insulates badly, one part of the repelled electricity is accumulated at the upper end of the conducting fibre; and, by discharging the spherule, alters the result. The lower the position occupied by the electrized body is, in relation to the group of spherules, the more will the repulsion occur from below upward, and the less will there remain on each spherule. A filament of gum-lac, 4 or 5 centimetres long, ceases to be sufficient during damp weather to retain the repelled electricity, when the body is placed below the group; the pith balls are seen to approach rapidly, and evidence the successive loss of their electricity.

There is one more condition to fulfil in this experiment in order to approach the natural phenomena, when we would imitate the influence of the globe on a cloud; it is to take a body having a large surface relatively to the small group of pith balls. In order to have the lateral re-actions sufficiently numerous, I give a diameter of 5 or 6 centimetres (2 to $2\frac{1}{4}$ in.) to the group of spherules, and I take a plate of 60 centimetres ($23\frac{1}{2}$ in.) in diameter to act on this group.

This large plate is altogether against the experiment; for, in nature, the inequalities of the ground, forests, isolated trees, houses, shrubs, and even the cereals under foot are active bodies to the limits of a cloud and its numerous folds.

Digitized by Google

To judge of the degree of the influence of these elevations, whatever they be, above the surface of the soil, there is no need to go and experiment, as we have done, upon a high mountain: the height of a tree, or that of a terrace, well away from all lateral influence, is sufficient to render evident the great difference between the tension acquired by induction, on raising the instrument one metre above a low plain, as that obtained by raising it in like manner one metre above a terrace 30 metres high. The electric kite demonstrates this fact at every instant; according as it rises or falls, the current increases or diminishes with great rapidity.

It is on account of the great tension acquired by bodies at a moderate height, that I have been obliged to make my observations in an inverse direction, namely, from above downward. The head of the observer is, oftentimes, so charged with electricity by induction, that he cannot directly read off the divergence obtained, because, on approaching, he makes it increase considerably. On the Faulhorn, the gold leaves were agitated at a distance of 10 metres, in ordinary weather; on my terrace, they were seen to open on presenting oneself at a distance of 2 metres, in moments that were slightly electric. It was only by operating from above downward, namely, by reducing the electrometer to equilibrium at its greatest elevation, and then bringing it down into a closed closet, that I am able to protect it from this induction,—it being understood, that I bear in mind the inversion of signs.

I have thought it useful to give these details, in order to prevent the comparison of results, which might not have been obtained by identical experiments.—[A.]

Note.—At the meeting of the Academy on the first day of the following April, a final note was read from M. Crahay. He acknowledges the accuracy of M. Peltier's experiments and reasonings; and in respect to the different views he had attained to, he says, "the cause of the disagreements between my experiments and those of M. Peltier, is, because in mine, there was scarcely any displacement of electricity among the globules; consequently, neither expansion nor contraction of the artificial cloud; whilst there was a displacement of fluid in M. Peltier's experiments." This concession being made, and both philosophers now understanding each other, we need not give the whole note. We merely add the concluding paragraph, in which the practical inference that M. Peltier had in view is granted:—"Before terminating, I think I ought to add that I have never doubted

Digitized by Google

that displacements of electricity occur in the clouds of the atmosphere, by the induction either of terrestrial bodies, or of clouds on celestial space; and, as these displacements occur, that a dilatation or contraction of the cloud follows, is what I am far from contesting. But the object of the present discussion was an artificial cloud formed of globules of elder pith equally electrized, and between which no passage of fluid was at first supposed."—Ed.

LXIX.—*On a new method of increasing, to an unlimited extent, the electromotory power of the Galvanic Current.** By J. C. Poggendorff. From Poggendorff's "Annalen," vol. lx. p. 568.—(Translated and communicated by W. G. Lettsom, Esq.)

During the course of an investigation, the results of which it is my intention to publish shortly, I hit upon a principle for strengthening the intensity or tension of galvanic currents, which I believe to be novel in its application, and which, independently of the principal object that I had in view, is perhaps of sufficient interest to justify its being noticed here.†"

It is well known that, if two homogeneous metal plates (for instance two strips of platinum) placed in a conducting fluid, are connected with a voltaic battery, they almost immediately assume the condition, which is termed polarized, the effect of which is to reduce materially the current of the battery employed; and that, on being detached therefrom, there is developed in the wire connecting such plates a current in an opposite direction, of limited duration it is true, but nevertheless of considerable energy. It is also well known that a whole series of such pairs of plates may be thus polarized, as it is termed. Ritter's secondary pile, an instrument which in its time attracted such attention, and which decomposes water, affects the electrometer, produces sparks, and gives shocks, involves a similar principle of polarization.

To render such secondary piles active,—of themselves they are powerless,—no other method was hitherto known than the employment of voltaic batteries, composed of a vast number of pairs of plates, and the current of which is therefore of great intensity; but the secondary current thus developed

* Vide notice of this paper, Elec. Mag. No. 5, p. 392.

† This paper was read before the Berlin Academy of Science, 21st Dec. 1843.

Digitized by Google

never possessed a greater or even so great an electromotory power as the one to which it was due.

From a detailed examination that I lately instituted with respect to Grove's gaseous battery, which is simply a secondary pile, and as I purpose showing only an imperfect one,* I was led to remark that, for charging such secondary piles, a primary one, consisting of as many or more plates, might be dispensed with, and that the charge may be imparted, every bit as well by means of a single pair, however great the number of the plates of the secondary pile may be; and hence we are put in possession of a method, which enables us to raise the electromotory power of the galvanic current to an unlimited extent.

The method of performing this is very simple. Suppose we have a series of platinum plates arranged pairwise in cells charged with diluted sulphuric acid; let one plate of each cell be designated by H, and the other by O. The former method of exciting a secondary pile consisted in connecting the H of each cell with the O of the following one, by means of a wire, and then allowing the primary current to traverse the whole series of cells from one end to the other. For this process, if at least the action of the secondary pile was required to be at all considerable, it was necessary that the primary pile should consist of at least as many pairs of plates as the other one.

My method consists in this, namely, I first of all connect all the H's with the zinc, and all the O's with the platinum of a single pair of Grove's battery: by this means the whole of these plates become polarized or charged, the H's all being invested with a film of hydrogen, and the O's with one of oxygen. All the plates become polarized equally, the amount of this polarization being precisely the same as what it would be, had only a single pair, presenting a surface equal to theirs in the aggregate been connected with the primary pair. When this connection has been maintained for a certain time, I rapidly break it, and connect with each other, so as to form a battery, the plates, in their then charged state, bringing a voltameter also into the circuit, supposing it to be my wish to observe the chemical effects of the secondary current.

The secondary current thus developed, possesses, speaking in a general way, an electromotory force exceeding that of the primary battery, as much as the number of pairs in the secondary pile exceeds the number of those in the primary one, and although (in consequence of the plates becoming

* If Grove's gaseous battery is so imperfect an instrument, it will of course be Poggendorff's pleasing duty to improve it materially.—Translator.

Digitized by Google

less completely polarized, the more there are of them) the electromotory force does not become infinitely great as the number of the plates is increased, yet it will go on augmenting more and more as the resistance in the primary pile is diminished.

The secondary current is, however, but of short duration, and this duration diminishes in the ratio in which the electromotory power is raised. We easily see how this is, on reflecting that the secondary pile, on having its charge imparted to it, for every equivalent of water decomposed in the primary pile, receives, it is true, the component parts of an equivalent of water decomposed in it; but that those component parts are divided among the whole of the cells; so that each cell, therefore, calling their number n, receives the component parts of but $\frac{1}{n}$ equivalent, in other words a smaller quantity the greater the number n, of the cells is. The reunion of the component parts of this $\frac{1}{n}$ of an equivalent, and that it is that brings about the secondary current,—the resistance in the primary and secondary piles being equal,—will evidently be brought about in nth of the time required by the primary pile for the decomposition of a complete equivalent.

It follows from this, that if it is proposed to apply the secondary current to anything beyond the production of a momentary shock, it will be necessary that the operation indicated above should be very frequently repeated. By the aid of the hand alone, this would be quite impracticable; for even one single operation, when thus performed, occupies so much time as to cause the loss of by far the principal part of the effect produced.

By means of a little mechanical arrangement, a kind of balance-break, similar in its construction to the apparatus formerly used for simply changing connections, the charges and discharges of the secondary pile may be very easily and rapidly brought about.

In order to avoid being made to wait by an instrument-maker, I have myself constructed such a balance-break out of a couple of small pieces of wood, a little mercury and a few copper wires; and, by the aid of one finger, I can now, without the least inconvenience, perform this double operation from two to three hundred times in a minute. There is thus obtained a current, intermittent it is true, but the action of which may be continued as long as one likes, and which may be applied to various purposes.*

* The translator had not received the after numbers that were due of the "Annalen," from his New York bookseller, when the translation was communicated.—Ed.

Digitized by Google

Experimenters, whose means are ample, will easily produce very striking effects by applying to batteries of several hundred pairs of plates *of considerable surface*, the principle that I have here pointed out. As far as concerns myself, I found myself limited to a far more humble number. It was in my power to use but four pairs, every plate presenting on each side a surface of about $2\frac{1}{2}$ square inches. Unless I am mistaken, however, my observations with those plates have established the principle beyond a doubt, and demonstrated its applicability to large batteries.

As a primary pile, I used a single pair of Grove's construction. By means of such an arrangement, the water in a voltameter furnished with platinum terminals, is decomposed, as we know, only very sparingly. These plates, in point of fact, become merely covered with minute bubbles of gas, of which but very few become detached. Now, on connecting the break with this arrangement and with the secondary pile, the voltameter spoken of above forming part of the circuit, and then putting the break in motion, we immediately obtain a very energetic decomposition of the water, an evident proof that the electromotory power of the secondary current is considerably greater than that of the primary one employed to develope it.

With a voltameter whose plates exposed, on one side, a surface of about three square inches to water acidulated with sulphuric acid, I obtained from 5 to 6 cubic centimètres of the explosive mixed gases per minute, when the break made about 80 oscillations in that time.

Before instituting this experiment, I anticipated a still stronger effect. More mature reflection has, however, convinced me that even the above result may, in certain respects, be looked on as remarkable. For while those 6 centimetres of gas were collected in the voltameter, there must, according to well-known principles, and which Grove's recent experiments have indeed confirmed, have been an equal quantity of the mixed gases brought to unite so as to form water in each of the four cells of the secondary pile, this amount of gas having been previously liberated from the water by the action of the primary pile. The primary pile, therefore, which, without the use of the break, would perhaps scarcely have liberated 0·1 centimètre per minute, by the aid of that apparatus liberated 6×4 or 24 centimètres in that time. And yet this is not to be taken as half its effect, inasmuch as the pauses and the intervals when the circuit in the secondary pile was closed, necessarily took up more than half the minute.

Digitized by Google

There is even a decomposition of water observed when only two cells of the secondary pile are brought into action in the manner above described; but the effect is then weaker. I obtained 1·5 centimètre of the mixed gas per minute. The result naturally depends on the action of the break; the more rapidly it oscillates the greater is the amount of water decomposed, at least within the limits that I have investigated.

With a smaller voltameter, the four cells of the secondary pile, when excited by a single Grove's pair, gave off 4 centimètres mixed gas per minute. But subsequently when, instead of one, I used two of Grove's pairs in connection for charging the secondary pile, I obtained very nearly 8 centimètres in that time.

The effect of the secondary battery increases, therefore, with the intensity of the primary current. This is natural enough; but we see also that when the intensity has been increased it will be necessary that the number of the pairs in the secondary pile should at the same time be augmented, as likewise its conducting power, if it is desired that the effect should be increased too.

In the above instance, the power was indeed reduced. For the primary pile connected directly with the voltameter would have given about 20 centimètres of the mixed gases per minute; whereas, by the charge of the secondary pile, it gave only eight.

This holds good, however, only with regard to the practical effect, that is to say, to the operation of the secondary pile in the voltameter. The effect of the primary pile will always be increased by the use of the break, however few the number of pairs in the secondary pile may be; if at least those cells in the aggregate do not offer a greater resistance than does the galvanometer. In the case above cited, the primary pile, instead of 20 centimètres, gave at least 8×4, or in other words 32 centimètres, in the secondary one; whereas the latter for that very reason gave off only 1×8 centimètres in the voltameter.

It is generally evident that the chemical effect of the secondary current depends of necessity upon the galvano-chemical process in the primary pile, and that in this respect, therefore, the idea of bringing about a saving in the consumption of zinc from the use of a secondary pile can never come to anything. Supposing the latter to decompose an equivalent of water, there must also in each of its n cells be an equivalent of water formed; and these n equivalents always presuppose that, in the primary pile, (if composed of a single pair) there have been electrolytically taken up n equi-

Digitized by Google

valents of zinc, that is to say, precisely the same number which, for producing an equal effect, must have been consumed by the secondary pile, supposing the positive element of the latter had been zinc, instead of hydrogen. The primary current would, indeed, have consumed $2 \times n$ equivalents of zinc had it been developed by a battery composed of two single pairs. The use of the breaks and the secondary pile is limited to the advantage of being able by their means to take up electrolytically in the primary pile an amount of zinc which otherwise would not be dissolved at all, or at least, not in the same time. The amount of electricity circulating in the same unit of time is increased, but this amount is not greater in the secondary than in the primary pile.

On employing a primary pile consisting of two of Grove's pairs, it will, moreover, strike us that the energetic decomposition of water, which that current developes in the cells of the secondary pile, as soon as the break is allowed to be at rest in the position closing the primary circuit, is, as far as the eye can judge, instantly suspended, as soon as a rapid motion is imparted to the break. Now it is evident that the minute quantity of gas set free upon the plates, during the short intervals of the intermittent action of the primary pile remains attached to those plates without assuming the form of bubbles, until destroyed or again made to resume the form of water upon the closing of the secondary pile.

If it is desired to increase the chemical effect of the secondary pile, the chemical effect of the primary one must, as before said, be also necessarily increased. Such an increase is not, however, wanted when an augmentation of only the electromotory power is wanted. The latter increases regularly with the number of the cells in the secondary pile, and it is, therefore, in our power to carry it to any extent we like. For obtaining powerful effects it is naturally advisable to increase this power as much as possible in each separate cell.

There is, as has very recently been shown by Lenz, Wheatstone and Daniell, a maximum in the polarization or electromotory counter-action caused by the aggregation of the constituents of water, in a gaseous form on the plates of a secondary pile; and this maximum may be held to be pretty nearly attained by a Grove's battery of two pairs. Such a battery, therefore, will be all that is required for the development of electromotory power to any desired extent,—for producing sparks, therefore, or giving shocks to any amount we wish,—provided we only increase the number of the pairs in the secondary pile in a commensurate manner;

Digitized by Google

and, at the same time, diminish the resistance of the primary pile, or, should circumstances not admit of our doing this to a sufficient extent, by lengthening the duration of the operation of the primary current.

I regret that, from the reasons to which I have alluded, it was not in my power to follow up this portion of the subject, as far as I could wish. I have, however, arrived at the conviction that a secondary pile, excited by a single Grove's pair, gives sparks, whether consisting of *four*, of *three*, of *two* pairs, or indeed of even *one* pair. In the latter case the sparks are but weak, though perfectly recognizable. This is probably the first time that electric sparks have ever been produced with a single pair of polarized platinum plates.

What is sufficiently remarkable, all these sparks, with the exception of those produced by the single pair, appear only on *closing* the secondary pile, not upon breaking the circuit. They always made their appearance after the sparks which, on the preceding interruption of the primary current, were visible at the other side of the break.

With a single pair of platinum plates of larger size, each plate presenting on each side a surface of nearly 29 square inches, French measure, I nevertheless obtained a spark on breaking the circuit, and this several times in succession without in the meantime again charging the plates with the primary pile. A spark on closing the circuit was also seen only occasionally, but I will not distinctly say that this was a genuine closing spark, for the employment of mercury may, as we know, lead us into error.

There are two respects in which the subject of this communication appears to me to be of peculiar interest.

First, with relation to the question whether an electric current can pass through water without decomposing it. Opinions differ upon this point, as we know, and I myself have entered into a discussion with Martens upon this subject.* I have maintained the opinion that an electric current, be it as weak as it may, cannot pass through water, without decomposing it; and I have only been strengthened in this view by what I have now observed.

A Daniell's pair we know does not visibly decompose water, between platinum plates; the current however of such a pair is not reduced altogether to zero by those plates; on the contrary, a sensitive galvanometer indicates distinctly an appreciable residuum, and it may now be asked, has this been conducted only through the water, or has there been a decomposition thereof as it passed? It does not appear to me to

* See Poggendorff's Annalen, vol. lv. p. 450., and vol. lviii. p. 252.

Digitized by Google

admit of doubt that, there must, previously at least, have been a decomposition of water; for, on connecting the break with the Daniell's cell and the secondary pile, the latter indicates, in its voltameter, what is relatively quite a considerable decomposition of water, that is to say, 1·5 centimètres of gas in five minutes. This decomposition of water can, however, arise from no other cause than this, namely from the Daniell's cell having first set free the constituent parts of the water upon the plates of the secondary pile.

The second point of view, in which the method here described, of charging a secondary pile, becomes a point of interest, is one from which we are led naturally enough to enquire whether in the case of electrical fish, nature may not have had recourse to some such similar arrangement. The electrical eel, as we know, posseses an organ, the arrangement of which is analogous to that of a voltaic battery. Might not this possibly be but a secondary pile, whose office it is to increase the electromotory power of a current, which is conducted to it from a source of electricity, of relatively very low tension, situated in the animal's brain? I content myself with simply alluding to these questions; to others be it left to come to a decision upon them.

In all the experiments above referred to the effects due to the secondary current alone have been discussed; for the construction of the break is such that, when that current circulates, the primary one is intercepted. There is no peculiar difficulty, however, in obtaining also by means of the same break, should it be desired, the conjoint effects of both currents: all that is required for that is a different connection of the wires. I have tried the effect with a single Grove's pair and one pair of platinum plates, (the large ones) in which case alone the experiment is possessed of interest, and I obtained a very brisk decomposition of water.* On this occasion we can see most clearly how much is due to the duration of the charge. On placing the break in such a position that the primary current alone may act in imparting the charge and leaving the break thus for a minute, and then turning it over so that both that pile and the secondary one united are brought to combine their energies in the voltameter, a brisk decomposition will occur, lasting a minute and a-half or more. Were the charge on the other hand, only instantaneous, the decomposition of the water lasts also but a little while. The like is also observed in those instances where, as in the former experiments, the effect of the secondary current is kept apart from that of the primary one, and indeed, generally

* Vide Grove's Experiments on this subject, *Elec. Mag.* p. 314.—Ed.

Digitized by Google

speaking, in all cases where the primary current is relatively weak, and the surface of the plates to be charged considerable.—[L.]

LXX. *An Account of a new form of Galvanic Battery, with a notice of some Galvanic Effects obtained with a single metal and a single exciting liquid.* By JAMES H. PRING, M.D. From the Author.

I. *A new form of Galvanic Battery.*—The galvanic arrangement, which I have first to describe, is one, in which sulphuric acid is employed as the exciting liquid:—it consists of a cylindrical glass jar, eleven inches in height, and five inches in diameter, containing the battery immersed in the acid and water. This jar is mounted on a mahogany foot below; and above, is furnished with a cover of the same material, varnished on its under surface, and fitted by a deep groove to the circumference of the glass. In the centre of the wooden cover, is a circular aperture, two inches in diameter, to admit the introduction of a rod of amalgamated zinc, without removing the whole cover; and into the aperture is loosely fitted a plug of wood, having a small hole through the centre to allow the passage of the wire, by which the zinc rod is suspended. Immediately around the aperture for the introduction of the zinc, are six smaller holes, into which are inserted the ends of a corresponding number of glass tubes, each tube being nine inches in length, and a quarter of an inch in diameter. The lower ends of these tubes are fixed by holes, similar to those in the cover, into a ring of wood, which is varnished. The object of the glass tubes thus arranged is to serve as a framework or support for a spiral coil of silver wire, which is wound around them from below upwards, the lower end of the wire being fastened to the varnished wooden ring, whilst the other end is carried through the wooden cover, on the upper surface of which it terminates in communication with a binding screw. The silver wire, which is platinized, is about twenty feet in length, and, from being flattened, forms a thin band about the sixteenth of an inch in breadth, the distance between each turn of the coil being about the eighth of an inch. In addition to the binding screw just alluded to on the upper surface of the wooden cover, there is also another, which is in communication with an arched wire or metallic support. The feet of this metallic arch are secured to the cover by screws;

Digitized by Google

and the arch itself, on which the zinc rod is suspended, stretches across the aperture in the centre of the cover. The length of the zinc rod, that has been employed, is five inches, and its diameter one inch and three-quarters; there can be little doubt, however, that its length may be considerably reduced with advantage.

Into each of the small glass tubes that serve to support the silver wire, is introduced a bundle of fine iron wire, which, during the action of the battery, is rendered magnetic; the lower ends of the tubes are of course sealed, to prevent the action of the acid and water on the iron wire.

From this description, which has been rendered somewhat prolix, it might be inferred that the battery is of a complicated form: the reverse is actually the case. . . .

From information kindly communicated to me by Mr. Crosse, of Broomfield, to whom electrical science stands so deeply indebted, it is in my power to state, more precisely, the relative value of the two forms of coil and cylinder, when used as the negative elements in a series of Daniell's batteries. In an experiment, in which twenty spirals of common bell-wire were wound around each separate porous pot, Mr. Crosse states, that he found "that sixteen of these coils, each forming a cylinder of nine inches in height and three inches in diameter, somewhat exceeded in powers of decomposition and ignition, seventeen cylinders of sheet copper, each formed out of a plate nine inches square, and rolled up." The form of a spiral coil of wire for the negative element, has been extensively adopted by Mr. Crosse for the last three or four years; and an account of the efficiency of a battery, in which this form of negative element was used, is to found in the third volume of *The Chemist*. . . . .

Whether the magnetism developed in the bundles of iron wire introduced into the glass tubes is to be regarded as an advantage or otherwise, I must leave to be determined by those who may enjoy fuller opportunities of investigating the subject than myself; it seems, however, not unreasonable to suppose that the action of the battery is in some way modified by this part of the arrangement, and it would be interesting to ascertain whether the modification is one of increase or of diminution of power. In the mean time, as a new feature in the construction of a battery, and as an additional fact, tending to illustrate the intimate connexion subsisting between the electric and magnetic forces, this part of the arrangement cannot be regarded as wholly devoid of value.

I have to acknowledge my obligations to Mr. Tylee, Che-

Digitized by Google

mist, of this city, who has done me the favour of testing the action of this battery on his galvanic clock; and he assures me, after many months' trial, that, for the purpose of working the clock, he considers it in every respect preferable to the ordinary platinized battery. Before closing the present notice of this battery, it may be observed, that, whilst it combines in itself the advantages of economy, efficiency of power, convenience of application, and elegance of form, it seems still susceptible of some new applications and of additional improvements. Thus, I have already applied it to the purpose of procuring the hydrogen for the Döbereiner light, for which it possesses the advantage of allowing amalgamated zinc to be substituted for the ordinary zinc in common use. In its application to this purpose, the circuit is of course always maintained closed, the hydrogen being evolved from the platinized silver wire. It is manifest also, in the ordinary employment of the battery, that, by a suitable mechanical contrivance for collecting the hydrogen and again permitting its escape, this gas may be made to serve the purpose of regulating the power of the current, the acid and water being alternately depressed by the elastic force of the confined gas, and again allowed to ascend during its escape, in place of the alternate ascent and descent of the battery itself, as under the employment of Mr. Bain's voltaic governor.

II. *Galvanic experiments with a single metal and a single exciting liquid.*—It may perhaps be permitted me, in concluding the present communication, briefly to notice certain galvanic effects obtained with a single metal and a single exciting liquid; the following being a description of these effects, and of the arrangement employed in producing them.

A porous pot of the common unglazed biscuit ware, six inches in height and three inches in diameter, filled with dilute sulphuric acid, and having on its exterior a spiral coil of copper bell wire, and a similar coil of the same metal in contact with its interior, was well insulated on an appropriate varnished wooden foot, and the ends of the wires connected with the galvanometer, when, on the occurrence of a free filtration of the fluid through the pot, the needle of my galvanometer (which though delicate is not astatic) was deflected from 70° to 80°.

It is worthy of remark, however, that with this considerable deflection of the needle, the current appears incompetent to effect chemical decomposition, neither is any perceptible effect communicated by it to the tongue, nor to the limbs of a recently killed frog; nor are these effects obtained, so far as I have been enabled to observe on a limited scale, by multiply-

Digitized by Google

ing the number of the pots, and connecting their wires together in the manner adopted in a battery composed of dissimilar metals.

In another experiment in which liquor potassæ diluted with water was substituted for the dilute sulphuric acid, the needle of the galvanometer was less powerfully affected; but the copper wires in this as well as in the former instance, were slowly dissolved by the solution. It may be mentioned further, that with a small porous pot, scarcely four inches in height and only one inch and a quarter in diameter, filled with a solution of cyanide of potassium, and furnished on its exterior with a coil of wire about six feet in length and the thirtieth of an inch in diameter, of pure gold, reduced from the chloride, and with a similar coil of the same wire in its interior, the needle of the galvanometer was deflected from 75° to 80°, on the occurrence of a free filtration of the solution through the pot.

These experiments, made many months since, are selected from amongst several others of a similar description, merely for the purpose of inviting attention to an interesting and extensive field of inquiry, for the fuller investigation of which, the arrangement just described appears to offer peculiar facilities.

Bath, September 4th, 1844.

LXXI. *On Phosphorogenic Emanation.* By Prof. Henry, of Princeton, U. S. From Proceed. American Phil. Soc., May 26, 1843, p. 37.

It has long been known that, when the diamond is exposed to the direct light of the sun, and then removed to a dark place, it shines with a pale blueish light, which has received the name of phosphorescence. The effect is not peculiar to the diamond, but is common to a long list of substances, among which the sulphuret of lime (Homburgh's phosphorus) is the most prominent. It is also an old fact, mentioned by Canton, that the phosphorescence is excited by exposing the substance to the light of the electrical discharge.

About three years ago M. Becquérel, of the French Institute, repeated the experiment of Canton, and discovered the remarkable fact, that the phosphorescence is excited in a very feeble degree, or not at all, when a plate of glass or mica is interposed between the spark and the sulphuret of lime, although the effect is not apparently diminished when a plate of rock crystal or one of sulphate of lime is similarly inter-

Digitized by Google

posed; or, in other words, he found that substances equally transparent, do not equally well transmit the exciting cause of the phosphorescence. Hence the old explanation of the glowing of the diamond, namely, that it is owing to the light which has been absorbed, and is again given off in the dark, could no longer be admitted; and Becquérel inferred from his experiments, that the exciting cause of the phosphorescence was due to an impression made on the lime by a radiation from the electrical spark, differing essentially from light, and to which he gave the name of the phosphorogenic emanation.

Biot afterwards made a series of experiments on the "permeability" of different substances, in reference to this emanation as it exists in the beams of the sun: and still later Matteucci, the celebrated Italian experimental philosopher, has investigated and extended the same subject.

The younger Becquérel also has published a memoir on the constitution of the solar spectrum, including its phosphorogenic properties. From the notices of the labours of these *savans* on this subject, as they were adverted to by Professor Henry, it appears that all their experiments, with the exception of those before mentioned, as made by M. Becquérel, were confined to the solar irradiation, and consequently they do not lessen the importance of a careful examination of the same emanation, as derived from a different source, and having a different intensity.

The investigations detailed in Professor H.'s communication relate, almost exclusively, to the emanation as derived from the electrical spark. The apparatus employed in the experiments was a Leyden jar, of the capacity of about half a gallon; and this was charged each time so as to give a spark between the rounded ends of two thick wires of about an inch in length. The sulphuret of lime was exposed to the light of the spark at different distances, in shallow leaden pans. The first experiments relate to an examination of a considerable number of substances in regard to their permeability by the emanation. The results of these, which were given at the close of the communication, will serve to corroborate the inference of M. Becquérel, that the exciting cause of the luminous appearance of the lime is not identical with light.

The next experiments are in reference to the propagation of this emanation. Two slits, of about the one-twelfth of an inch wide and an inch long, were made in two screens of sheet brass, and these slits were placed in the same plane with the path of the spark. After the discharge the sulphu-

Digitized by Google

ret of lime under the opening was observed to be marked with a narrow line of light well defined at its edges, and shaded off at its ends into a penumbra, the appearance being precisely in accordance with the laws of a radiation in straight lines from a narrow line of emanation. Experiments were next made to determine whether the radiation of the emanation takes place with the same intensity from every point of the length of the spark, or whether it is confined to the two extremities, or the poles of the discharging wires. For this purpose the slits were turned at right angles to their former position, so that the emanation could only reach the line from a single point of the spark. The experiments with this arrangement showed that the radiation is from each point of the line of the spark, but that it is much more intense from the two extremities. This curious result was verified by another arrangement, which allowed the impressions from different points of the spark to be at once compared with each other. Three slits were cut in a thick plate of mica, and this was placed immediately above the lime, so that one of the slits was directly under the end of each wire, and the other midway between the other two. When the discharge was passed over the plate, the lime under the middle slit exhibited a feeble phosphorescence for two or three seconds, and then became dark, while that under the slits at the end of the spark, continued to glow for more than a minute. This effect did not appear to be due to the diffusion of the spark at the middle of its course, since the discharge was from a Leyden jar, and the spark, as is usual, in this case, appeared in a single line of light of the same intensity and width throughout its whole length.

The phosphorescence was excited at a much greater distance than was at first thought possible. In a perfectly dark room, the light was observed for a few moments, when the pan containing the lime was removed to the distance of ten feet from the point of discharge. The intensity of the light and the time of continuance, however, diminish very rapidly with an increase of distance.

To determine whether the emanation obeys the laws of the reflection of light, a piece of common looking-glass was so arranged with the path of the spark, the slits in the screens, and the pan of lime, that the angle of reflection could be compared with the angle of incidence; but with this arrangement no impression upon the lime could be obtained, the want of permeability in the glass apparently preventing any reflection from the silvered side of the mirror. A plate of polished black glass was next used, so as to get the reflection from the anterior surface; the result, however,

Digitized by Google

was of the same negative character as before. It would, therefore, appear, that glass neither reflects nor transmits the phosphorogenic emanation except in a very small degree. When a metallic mirror was employed, a well-defined line of light was impressed on the lime from the reflected emanation, and from the position of this it was found that the two angles were equal.

The refraction and dispersion of the emanation were readily obtained, by employing for the purpose a prism of rock salt, instead of one of glass. The dispersion was shown by the conversion of the narrow line of light, by means of the prism, into a broad band.

The next question was in reference to the polarization of the phosphorogenic emanation; and in obtaining a satisfactory answer to this, several difficulties were encountered. Attempts were first made to polarize the beam by passing it through tourmaline; but it was found that this substance is less permeable to the emanation than even glass or mica. Nichol's polarizing prisms were next employed, but no impression could be made upon the lime through two of them; and since the emanation is not reflected by glass, and the polarization from polished metal is very feeble, these substances could not be employed in the process. At length an indirect method was adopted, which gave positive results. This was founded on an experiment of Melloni in his interesting researches on radiant heat. A pile of exceedingly thin plates of mica, prepared according to the method of Professor Forbes, of Edinburgh, was placed between the spark and the pan containing the lime, with its plane at right angles to the line joining the middle of the two. In this position of the pile no impression was made on the lime by the electrical discharge; but when the plane of the pile was inclined to the line just mentioned, so as to form with it the polarizing angle, a luminous spot was excited.

By this change in the position of the pile, the thickness of the path to be traversed by the phosphorogenic beam was considerably lengthened; and yet the permeability was much increased. This remarkable result could only be the effect of the successive polarization of the several parts of the beam, as they passed the several films of mica, and were thus prepared for a more ready transmission by the succeeding films.

After the emanation was found to be polarizable, it was important to determine if the intensity of the action on the lime would be different, in case the beam were transmitted through crystals in different directions, in reference to their optical axis: but no difference could be observed, when the

Digitized by Google

beam was passed through crystals of carbonate of lime and quartz, parallel and perpendicular to the axis.

From the foregoing results it is evident, that the exciting cause of the phosphorescence of the sulphuret of lime, is an emanation possessing the mechanical properties of light, and yet so different in other respects as to prove the want of identity. That the same emanation also differs from heat is manifest from the fact, that the lime becomes as luminous under a plate of alum as under a plate of rock salt, although these substances are almost entirely different in their property of transmitting heat.

Some experiments were also made to compare the phosphorogenic emanation with the chemical radiation. For this purpose a sensitive Daguerréotype plate, and a pan of sulphuret of lime, were exposed together to the light of the sky for five seconds. The plate by this exposure was marked with a photographic impression, but little or no effect was produced on the lime. Another sensitive plate and the same pan of lime were similarly exposed to the light of an electric discharge: the lime was now observed to glow, while no impression was produced on the plate. When, however, the plate was exposed very near to a succession of sparks, continued for ten minutes, with a plate of mica interposed, an impression was made.

The sulphuret of lime was also exposed, for several minutes, to the direct light of the full moon, without any phosphorescent effect. A sensitive plate, similarly exposed, according to the statement of Dr. Draper, receives a photographic impression. These experiments, although not sufficiently extensive, appear to indicate that the phosphorogenic emanation is distinct from the chemical, and that it exists in a much greater quantity in the electrical spark, than either the luminous or chemical emanation.

Professor H. remarked, that considering these emanations as distinct, he had reference only to the classification of the phenomena; for if they be viewed in accordance with the undulatory hypothesis, they may all be considered as the results of waves, differing in length and amplitude, and possibly also slightly differing in the direction of vibration.

The phosphorescence of the lime may also be excited by exposure to the light of a burning coal; and in this case the emanation is also screened by a plate of mica. It was also found, that the magneto-electrical spark from a surface of mercury, excites the luminous condition of the sulphuret; and it has long been known that heat, applied to the bottom of the vessel containing the article, produces the same effect.

Digitized by Google

To determine whether the phosphorescence could be excited by electro-dynamic induction, a quantity of the sulphuret was placed between two plates of quartz, and a covered copper wire was wound around the whole, so that the lime occupied the axis of a spiral. But when a discharge of electricity was passed through the wire, the lime gave no indication of phosphorescence: the same negative result was also obtained, when the sparks were passed through the bottom of the leaden pan.

It has been supposed, that the phosphorescence of the lime is due to the disturbance of the electricity of the mass of the substance, and the continuance of the light to the subsequently slow restoration of the equilibrium.* The result, however, of the following experiment would seem to be at variance with this explanation. The lime was thrown into a tumbler of water, and sunk to the bottom; but in this situation, when the spark was passed over the surface of the liquid, it became as luminous, and the effect appeared to remain as long, as when the exposure took place in the air.

Professor H. observed, that some of the experiments described by him can be repeated with common chalk, although it is not as sensitive as the sulphuret of lime. Some pieces of it, however, become luminous at a considerable distance, and it is not improbable that the chalk cliffs of England are sometimes rendered phosphorescent by flashes of lightning during a thunder-storm.

But the substance which gives the most brilliant light, although the light does not continue so long and is not as easily excited as that from the lime, is the sulphate of potassa. When exposed to the discharge of a jar highly charged, at the distance of a few inches below the spark, it glows for a few seconds with a beautiful azure light; and as this salt is not readily acted on by liquids, it was used to determine the permeability of different substances, by placing a crystal of the salt in the liquid to be tested.

It has long been known, that the sulphate of potassa often emits flashes of light during the progress of its crystallization; and it is probable that other substances, which are known to emit light under the same circumstances, may also be rendered phosphorescent at a distance by the electrical emanation.

The following is a list of substances which have been examined by Professor Henry, with reference to their permeability by the phosphorogenic emanation.

* Vide Mr. Pollock's Papers in *Proceed. Elec. Soc.*—Ed.

Digitized by Google

Transparent Solids. *Permeable.*	Transparent Solids. *Imperfectly Permeable.*
Ice.	Tourmaline.
Sulphate of lime.	Mica.
Quartz.	Flint glass.
Sulphate of baryta.	Crown glass.
Sulphate of potassa.	Saltpetre.
Sulphate of soda.	Tartaric acid.
Borax.	Hyposulphate of soda.
Citric acid.	Copal.
Rochelle salt.	Camphor.
Common salt.	
Alum.	
Horn (pellucid).	
Wax (do.)	

Transparent Liquids. *Permeable.*	Transparent Liquids. *Imperfectly Permeable.*
Water.	Muriatic acid.
Solution of alum.	Sulphuric acid.
Solution of ammonia.	Nitric acid.
Sulphate of magnesia.	Phosphoric acid.
Nitrate of ammonia.	Sulphate of zinc.
And all weak solutions.	Sulphate of lead.
	Acetate of zinc.
	Arsenious acid.
	Ammonia.
	Spirits of Turpentine.
	Alcohol.
	Ether.
	Oil of aniseed.
	Acetate of lead.

LXII.—*On the Development of Electricity by a Jet of Vapour.* Letter addressed to M. Quetelet by M. Peltier. From Bul. R. Acad. Brux. t. x. No. 4. p. 318. April 1, 1843.

(TRANSLATION.)

In the number of the *Philosophical Magazine* for January last (1843), Mr. Armstrong inserted a new note* on the electricity of vapours escaping from a boiler. He describes the modifications he has made in the jet, consisting in a thick tube of very dense and hard wood, and in the interior deviation of the column of vapours through a narrow opening.† The

* Vide *Elec. Mag.* No. I. p. 65.—Ed. † Ibid, No. III. p. 231.

Digitized by Google

result that he has obtained is very advantageous; for, by this means, he has procured seven times as much electricity as with a good machine, having a plate three English feet in diameter. Finally, he puts forth the idea that the cause of the production of electricity arises from the friction of the vapours against the sides of the tube,*—an opinion, which he weakens by a doubt at the end of his note. In preceding memoirs, he had attributed this cause at one time to the expansion of the escaping vapour; at another time to the condensation of the vapour that had escaped. As not any one of these explanations appears to me to be the true, permit me to direct attention to what I have said on the subject, and to what experiment has demonstrated.

It has been long known that the vapour arising from a saline solution, sometimes gives signs of electricity, and that more frequently it does not give any. It has also been known that these signs are only obtained when the temperature of the vessel is very high; but the cause of this necessity of a high temperature, or that of the anomalies, has not been pointed out. In consequence of the first observations made in England on the electricity of vapours escaping from a boiler, I communicated to the Academy of Sciences at Paris some of the results of my experiments, which were applicable to these observations and facilitated their solution.

The following is the *resumé* of the facts concurring in this phenomenon.

On pursuing the order of the phenomena presented by a drop of water, when projected upon incandescent platinum, I have found that in the vapour produced slowly, during the whole time that the liquid spheroidal remains suspended above the metal without contact, there is no electricity developed, whatever be the temperature of the vessel. That of the liquid remains at about 81° cent. (178° F.) if the insulation of the water is maintained, until the metal is below 112° (233·6° F.); and if the melting suddenly takes place over the whole surface of the liquid, a great quantity of vapour is produced, and it does not contain any more electricity than the preceding. But, when partial meltings occur at a temperature above 112° cent.; when, by the intervention of a deposit, of incrustations, or of water blackened or but slightly transparent, the spheroidal drop manages to touch the metal by one point, at a degree above 121·4° (250½° F.) or 135° (275° F.) &c., I will suppose the vapour produced at this spot has a pressure of 2, 3, &c. atmospheres; it suddenly

* Faraday's Researches on the influence of friction will be found in Nos. I. and II. of the *Elec. Mag.*—Ed.

Digitized by Google

breaks its aqueous envelope, is projected to a distance, and electrical signs are manifested. The higher the temperature is, at which the partial wetting takes place, the more does the elastic tension of the vapour increase, the more sudden and extended are the projections, and, in fine, the greater is the quantity of electricity collected. It is only at this instant that the vapour is accompanied by electricity;—it is neither before nor after these projections at high tension. I measured the temperatures of the vessel by means of thermo-electric pairs; and I was enabled to determine the relation existing between the elastic force of vapour and its electric tension.

These experiments are simple, nothing complicates them; they also present a great facility for reaching the cause of the electric phenomenon, and for discovering it, in the more complex and obscure experiments of the boiler.

Every chemical action produces an electrical phenomenon; this is a fact that has been acquired to science for 20 years. In 1837, I proved by experiment that every solution, however diluted it might be, is a chemical combination (*Journ. de l'Institut*, t. v. p. 159.); consequently, in the act of evaporation above a solution, the combined elements, by separating, produce the converse chemical action,—that of decomposition; and, hence, an electric phenomenon with signs contrary to the act of combination. But it is not enough that electricity be produced at the moment of the formation of the vapour: it is essential that the contrary conditions which constitute the phenomenon be maintained insulated, in order to their being appreciated by their ultimate effects. It is the same when a solution of potash is poured into nitric acid; their combination presents no exterior electric sign, notwithstanding the enormous quantity of electricity produced; in order to obtain the manifestation, an apparatus must be arranged fitted for collecting separately the two states constituting this phenomenon.

In every spontaneous evaporation, in every slow evaporation, even that of boiling water, the vapour is not separated with sufficient suddenness from the rest of the liquid, so as to carry away and retain the electricity of the chemical action of its separation: the neutralization by return is made with too much facility in the moist atmosphere touching the surface of the liquid; so that the vapour is unable to carry away the smallest particle of electricity. But if, on the contrary, its vapour is formed at high tension, its separation from the liquid is sudden and instantaneous; a large insulating space suddenly intervenes; it then preserves its electricity of che-

Digitized by Google

mical decomposition, and leaves to the vessel the contrary electricity.

A boiler is but another means of obtaining vapour at high tension, as it suddenly separates from the liquid; but the form, which we are obliged to give to it, is very much opposed to the free liberation of the electricity; so that we obtain comparatively very small quantities of what is really produced. These quantities not only depend on the internal pressure, but also on the jets, which oppose or facilitate the neutralization by return. Thus it is that powerful locomotives have been seen to present but feeble electrical results, whilst a small boiler may give them on a considerable scale. In my experiments with a very small Papin's digester, my results were greater, in proportion as I gave a more rapid escape to the vapour at the moment of its formation, still preserving it at the same tension.

If we compare the quantities obtained with a small spheriod of water placed on a metal plate with those from an ordinary boiler, we shall be struck with the inferiority of the latter. If the boilers gave quantities of electricity equivalent to the mass of vapour produced, in comparison with those given by the spheroids of water, we should arrive at the conclusion that of all the means hitherto employed to obtain electricity, there are not any which could rival that of the evaporation of saline solutions at a tension of 5 or 6 atmospheres. Unfortunately, the apparatus employed in every way facilitates neutralization by return, and allow only a very feeble portion to escape. [A.]

LXXIII. *On the Electricity of Vapours from High-Pressure Boilers.* By M. Peltier. Read before the "Société Philomatique, Paris," Aug. 3, 1844. From "L'Institut," Aug. 7, 1844.

(TRANSLATION.)

Since the discovery made in Sept. 1840, by the mechanician W. Patterson, of the electricity possessed by the vapours of high-pressure boilers, numerous experiments have been made in order to recognize the cause, and to determine which were the most favourable arrangements and circumstances for the reproduction of this phenomenon. Enquiry was also made whether this power did not concur in the explosion of the boiler.

Among the philosophers who have been most occupied on

Digitized by Google

these questions, Messrs. Faraday and Armstrong must be placed in the first rank. From their numerous experiments, they have deduced a theory which has hitherto succeeded in obtaining the assent of but a small number of philosphers, and which it is impossible to admit.

Previous researches on the cause of the electricity of atmospheric vapours, have made the intelligence of these new phenomena easy to me; I pointed out at the very period of their discovery, the cause of the electricity of vapours produced in the open air, and without any other pressure than that of the atmosphere. In a subsequent letter, to M. Quetelet, communicated to the Academy of Sciences, at Brussels*, my explanation extended to various electrical productions, both to those which take place under the simple pressure of the atmosphere, and to those which arise from a pressure of several atmospheres. This explanation does not appear to have been adopted by Messrs. Faraday and Armstrong, for, in a later memoir, they persisted in the idea already put forth, that the friction of the water against the sides of the jet, was the only cause of this phenomenon. Being desirous of taking up this question, I took advantage of a journey to Belgium, which I have just made, in order to renew and to repeat under new forms, these same experiments, by examining the vapours from locomotives, those from steam-boats, and finally, the dry and smoky vapours that escape from chimneys. I am about to communicate to the Society the results of these experiments.

I will first call to mind some of the circumstances necessary to the production of the phenomenon, and without which it cannot take place.

There are two means of producing electrical vapours by an elevated temperature, which must not be confounded. The first is that of calefaction in the open air, without any other pressure than that of the atmosphere. In this case, electrical manifestations are obtained with saline solutions alone, which are projected in a capsule that has previously been reduced to a high temperature. The projected liquid *calefies*, it becomes insulated from the vessel; its temperature does not exceed 90° or 92° (194° or 197° F.), whilst that of the vessel may attain reddish white heat. The water gradually vapourizes, without giving any sign of electricity; but, when the solution, in consequence of the evaporation, becomes supersaturated and crystals of salt are deposited on the sides of the capsule, partial contacts are established by their intervention between the liquid and the vessel; those particles of the liquid that have

* Vide present No. of Elec. Mag. p. 450.

Digitized by Google

come into contact, are suddenly transformed into elastic vapour, the tension of which is proportionate to the temperature at which it has been formed. It is this vapour alone—the vapour that owes its origin to the contact of a vessel heated above 112° (233·6° F.)—vapour that possesses a tension of more than one atmosphere; it is this vapour alone that preserves the electricity which is due to its transformation—to its passage from the liquid to the gaseous state. The more elevated the temperature of the capsule is at the moment of contact, the greater is the quantity of the electricity preserved; below 110° (230° F.) no signs of electricity are obtained. This anticipated contact of the vessel is greatly favoured by blackening the liquid with a little ink.

Vapour produced at a temperature that can be raised beyond 200° (392° F.) possesses considerable elastic force; it is suddenly separated from the rest of the liquid, and instantly places between them a large insulating space, which enables it to preserve the electricity due to its formation.

If, instead of saline solutions, distilled water is projected into a crucible heated to several hundred degrees, the water is calefied like the solution, but it preserves its calefaction until the temperature of the vessel has descended below 110° (230° F.), if no cause has induced the anticipated contact. The temperature being thus lowered, and the calefaction having ceased to insulate the liquid, the water is transformed into a vapour which has the elastic force of only one atmosphere; hence, it rises too slowly to place an insulating space between it and the rest of the liquid, and the electric phenomenon is completed by returning to a state of neutralization, by means of the conductibility of the column of vapour.

The second means of producing electrical manifestations in vapours, is that of high-pressure boilers. With these apparatus, we give as high a temperature to the liquid as we desire, and the vapour that escapes, possesses a proportionate elastic force. This means advantageously supplies the place of salts, because it permits of our operating with every kind of liquid, even with distilled water, and of thus obtaining electrical manifestations at a desired tension. With this apparatus, experiment shows that we require:—1st, that the vapour be projected by an internal pressure of several atmospheres: 2nd, that it be accompanied by a projection of water. If it comes out *dry*, without being accompanied by particles of water, it gives no sign of electricity; consequently, the electricity is not brought out from the boiler by the escaping vapour, but it arises from the vapour of the drops of water that are projected at a high temperature, and a portion of which is imme-

Digitized by Google

diately vapourized. This absence of all electricity from the vapours within the boilers, destroys the idea that had been advanced of the part played by this power, in the explosion of boilers.

The preceding facts having convinced me that the preservation of the electrical phenomenon depended on the quick separation of the liquid and the vapour at the moment of its formation, I thought that the mere progression of the producing body, when it is rapid, might be sufficient, within certain limits, for the separation of the two electrical states; and that the velocity of locomotives might demonstrate it.

On the 8th, 9th, 11th and 13th of last July, I ascended an open waggon placed at some distance from the locomotive of a train; by standing up and elevating an electrometer, terminated by a polished copper ball, I was able to establish the fact to be just as I had anticipated; and, during an excursion to Gand, I was able to give M. Quetelet the opportunity of witnessing it. In consequence of the progression of the train, we passed beneath the column of vapour which the locomotive rapidly gave off; thus placed under its influence, we were able to prove that the electrical signs were more considerable as the train proceeded with greater velocity, and as the column of vapour was more rapidly broken up into particles (*mamelons*, Fr.) When the train diminished in velocity, near the stations, the column of vapour became more united, less mammilated, and the electrical signs then diminished in the same proportion; and even all signs ceased to appear when the train was near stopping.

It was equally easy for me to prove that, when the atmosphere favoured a greater evaporation,—when the globular vapour that prevailed above us was more rare, and, consequently, when the new elastic vapour was more considerable, the signs of positive electricity increased; when, on the contrary, the bulk of the column of vapour reached us, and the semi-transparent particles were formed behind us, the signs of this opaque column were negative. Frequently also, when the rime that fell beneath the column of vapour, moistened the ball of the electrometer, the *positive* sign suddenly disappeared, and was replaced by the *negative*. Thus the elastic vapour formed in the open air was *positive*, and testified its elastic state at a distance, by its influence on the instrument, whilst the drops of water, not vaporized, that remained from those which had furnished the vapour, were negative, and occasionally came and changed the signs, by discharging themselves on the ball. At the head of the column, signs of positive induction alone were obtained; at

Digitized by Google

the tail, beneath the compact column, negative signs alone were obtained; and, intermediate, the two signs alternated according to the velocity of the train, the quantity of the prevailing vapours, the rapidity of the evaporation, and the state of the sky.

Between Liège and Namur, I repeated these experiments with equal success, on the steam-boat, *John Cockerill*, in ascending the Meuse, at the moment when the steam was let loose (*lâchait*, Fr.); moreover, during the whole passage, I was able to repeat the same experiments, under the influence of dry vapour, namely, of the smoke of the chimney. When I placed myself forward, far from the influence of the column of smoke, I found, on raising the electrometer two metres (6½ feet), a positive divergence of ten degrees. On placing myself aft, under the influence of the column of smoke, I could not obtain any electrical sign. This column of smoke, therefore, possessed a negative tension sufficient to neutralize from above downward, that of the globe, which was acting from below upwards; it simply carried away what it borrowed from the globe, it was negative like the globe; and no other electricity was formed in its substance, since there was no change of state. If the wind or the deviating motion of the boat freed me from the column of smoke, I found aft, as I had found forward, the ten positive degrees for a similar observation.

I have thought that these experiments possessed sufficient interest to be communicated to the Society, and that they would contribute toward making the true course of the electric manifestations of vapours, arising from boilers and from all elevated temperatures, better understood; and that they would oppose the admission of the hypothesis, impossible in my opinion, which attributes the electricity, that is produced, to the friction of a liquid against solid sides. [A.]

LXXIV.—*Application of Electricity to the improvement of the Manufacture of Iron.* From "Mechanics' Magazine," No. 1097, Aug. 17, 1844.

"The attention of the iron-masters has been attracted to a process of considerable importance lately introduced into their manufacture. The application of electricity, to supersede several of the expensive processes, has it is stated, been tried in the Welsh and Derbyshire furnaces with satisfactory results. It appears that the costly fuel and labour required for the purification of the ore from sulphur, phosphorus, and

Digitized by Google

such subtle elements, create its high market value; and these being all electro-negative, have induced the new process, whereby the impure stream of metal, after flowing from the blast, is in its moment of consolidation subjected to a powerful voltaic battery, which so disengages the impure components that in the process of puddling they are readily extracted. The London blacksmiths, it is stated, have tested this iron after a single re-heating, and pronounce it equal to the best metal in the market. By the same process an experiment was tried by Dr. Ure, by whom a soft rod of iron was held in contact with a moderate red heat, and that gentleman is understood to have stated that in a few hours the metal was converted into steel. Should these facts prove what they seem, they are calculated to affect most seriously this important branch of our trade."—*Times—City Article.*

The process referred to in the above extract, is that for which Mr. Arthur Wall obtained a patent, November 18th, 1843. It is thus described in his specification, enrolled May 18th, 1844:—

"In casting a bar or similar mass, the electric current is caused to traverse from end to end, by conductors so arranged, that when the metal runs into the mould it may complete the electric circuit, or by means of a wire or wires, passed from one end of the mould to the other. If the castings are horizontal, a piece of wrought iron or other conducting material is placed at each end of the mould, which is made of sand, or other non-conducting substance: these conductors are then connected by wires with a galvanic apparatus, or voltaic pile, or electro-magnetic or other battery; so that, when the melted iron is run into the mould, it will complete the electric circuit; and the patentee prefers to continue the electric current for some time after the iron has solidified. When the castings are vertical, a similar arrangement is made for the passage of the electric current through the metal, by placing a conductor at the top and bottom of the mould, in such a manner, that the electric circuit will be completed the moment the mould is filled with liquid iron.

"To apply electricity to iron in a smelting furnace or cupola, a wrought-iron rod is introduced through or at the side of the tap-hole, until it comes in contact with the melting metal, and another wrought-iron rod is introduced at the upper or posterior part of the hearth, or through one of the tuyere holes, until it reaches the metal; the outer ends of these rods being then connected with a battery, the electric current will be caused to pass through the iron, care being taken not to continue it so long as to entirely to decarburate

Digitized by Google

the iron, and bring it to a malleable state. When the electricity is to be applied to the iron in a puddling or balling furnace, two iron rods are also used, one of which is inserted into the fused metal, and the other end is connected with a battery; the other rod is attached to an insulating handle of porcelain, pottery, or other non-conducting substance, and a wire from the battery is connected to it, close to the handle. By means of the handle, the extremity of the rod is caused to traverse the iron in its melted state, or during its transition to the solid state, and the electric current will therefore pass through the metal in every possible direction."

LXXV. *On the Electricity produced in the Manufacture of Paper.* By W. G. Armstrong, Esq.

(To the Editor of the Electrical Magazine.)

Newcastle-upon-Tyne, 16th Sept., 1844.

Dear Sir,—Most persons, who have witnessed the modern process of paper making, have had their attention directed to the electrical condition of the paper, in the concluding stage of its formation; but I am not aware that any notice of the subject has yet been published. I have lately visited several paper mills, for the purpose of observing this phenomenon; and as it appears to me to possess considerable interest, I am induced to transmit you an account of it, for insertion in the *Electrical Magazine*.

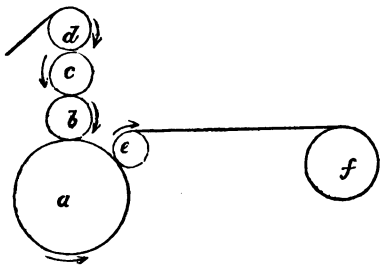
For the information of such of your readers, as are not fully acquainted with the machinery employed in the manufacture of paper, it may be proper to explain, that in Fourdrinier's paper machine, which in its present improved form is now almost universally used in this country, the pulp which forms the material of the paper, and which is prepared by grinding rags amongst water, is deposited in a thin layer, upon an endless web of wire cloth, which operates as a strainer in separating the fibrous substance of the rags, from the water in which it is suspended. The wire cloth revolves upon a number of small rollers, so as continually to present a fresh surface for the reception of the pulp, which is thus carried forward as fast as it is deposited. By this means a continuous sheet of incipient paper is produced, which, on leaving the wire cloth, is subjected to the pressure of rollers, for the purpose of expelling a further portion of the water, and giving tenacity to the fibres. It is then conveyed upon an endless web of felt or flannel put in motion by the machinery, to the drying rollers, which are large hollow cylinders made of cast

Digitized by Google

iron, and heated by the admission of steam through their axles which are tubular. In passing over these rollers, the paper is accompanied by the web of flannel, between which and the surface of the rollers the paper is enclosed. The drying rollers are not in contact with each other, and the paper, therefore, sustains no pressure during its passage over them, beyond what is occasioned by the tightness of the flannel. The paper is then conducted, in a dry or nearly a dry state, to the glazing rollers, and it is on leaving these rollers that its electrical condition is manifested.

The construction of the glazing rollers varies in different machines, but the arrangement which appeared to me to be more effective in exciting electricity than any other I had an opportunity of examining, is that which is represented in Fig. 1. The large roller *a* which is two feet in diameter, and made of cast iron, is heated by steam like the drying rollers, and imparts considerable heat to the three superposed small rollers *b*, *c*, *d*, as well as to the fourth small roller *e*. These four small rollers are all made of solid cast iron, and are each five inches in diameter. They are only confined *laterally* at their axles, and are therefore at liberty to press downwards with their whole weight; so that the paper, the course of which is indicated by the arrows, sustains first the pressure of one of these rollers, then of two, next of three, and finally again of only one. The paper on leaving the last roller *e*, is in a finished state and is then rolled up at *f* as fast as it comes from the machine.

Fig. 1.



The electrized state of the paper becomes perceptible immediately after the sheet quits the last glazing roller; and when a person's hand is presented, either to the roll of finished paper, or to any part of the sheet between the roll and the glazing rollers, sparks are emitted by the paper which sometimes reach to a distance of several inches; but they produce very little sensation and are scarcely visible in daylight. When the excitation is strong, a continual crackling noise is distinctly heard, which probably arises from the electricity retroceding from the paper to the glazing rollers.

In order to collect the electricity as effectually as possible from the paper, I provided an instrument, which consisted of

Digitized by Google

a row of metallic points, insulated by a glass handle. When the points of this collector were applied to the paper, the instrument yielded much more pungent and brilliant sparks than I could obtain direct from the sheet; but in consequence either of defective insulation or of some other unperceived cause, the sparks from the collector were not in general so long as those from the paper. The maximum length of the spark yielded by the collector was about two inches, while in some instances I obtained from the paper an attenuated spark of more than double that length; and I was told that when the interior of the building was darkened, sparks might frequently be seen darting through a space of eight or ten inches between the surface of the roll and the iron work of the machine.

I repeatedly charged a small Leyden jar from the collector, and gave electric shocks to persons who happened to be present; but the quantity of electricity evolved, did not prove to be so great as appearances had led me to expect.

FIG. 2.

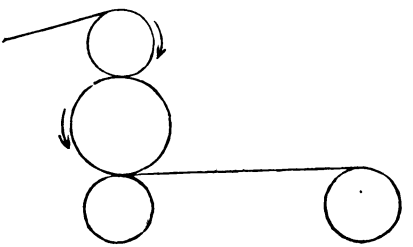


Fig. 2 represents another series of glazing rollers which I also saw in operation, but which appeared to act less efficaciously in exciting the paper than those I have already described. It is quite possible, however, that the inferiority of the effect, might be owing to some difference in the quality, or dryness of the paper, and not to an unfavourable construction of the glazing rollers.

I believe I am correct in asserting that, so far as our present knowledge extends, *friction*, or the attrition of two surfaces against each other, is the only mechanical process by which electricity can be excited, in a degree at all approximating to that in which it is developed in paper, by the action of the glazing rollers; and yet a moment's consideration will suffice to show, that, inasmuch as the paper moves in the same direction, and with the same velocity, as the surface of the rollers, there can be no appreciable friction in the case. In fact, the only recognized source, even of weak electricity, which appears to have any place in the operation of rolling, is *pressure, with subsequent separation of surfaces.* I am unable, therefore, to conjecture any other cause for the high excitation of the paper, than the pressure which it

Digitized by Google

sustains in passing between the glazing rollers and the separation which takes place on its leaving them. This hypothesis receives some degree of support from the fact, that I could discover no electricity in the paper while it remained in contact with the rollers, although I used a gold-leaf electroscope as a test.

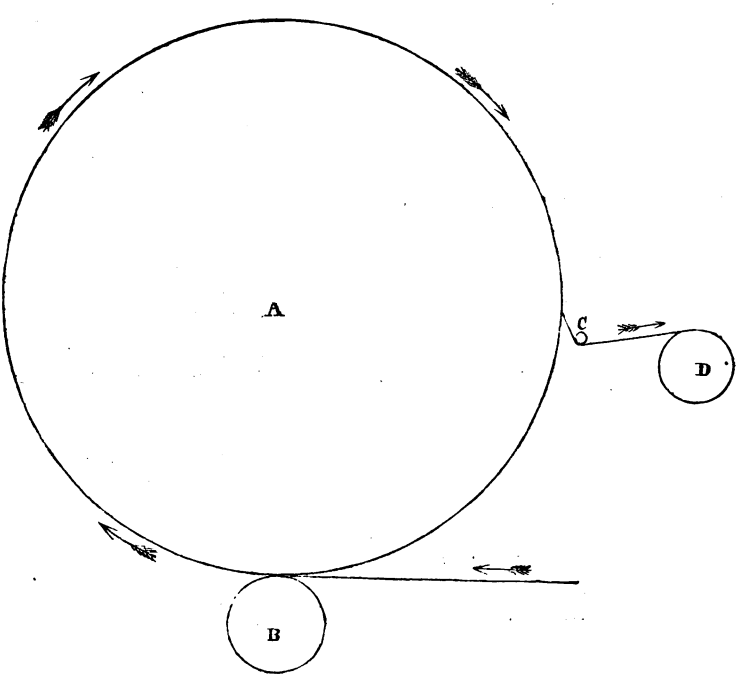
In one or two instances I found the paper slightly electrical between the drying cylinders and the glazing rollers, but in general, it was free from electricity until it had undergone the process of glazing.

The description of paper which the several machines to which I have alluded, were employed in making when I saw them in operation, was *printing* paper of various qualities; and the electricity I collected was in every instance negative.

Thus far I have spoken exclusively of machines upon Fourdrinier's principle, and have next to notice a machine of American invention, which I had likewise an opportunity of inspecting; and in which the paper produced is also extremely electrical, although it undergoes no pressure whatever, except in the *wet* state.

In this machine, Fig. 3, there is only one drying roller A, which, however, is of very large dimensions, being nine feet

FIG. 3.



Digitized by Google

in diameter. Against this roller the paper is pressed in a wet or plastic condition, by the action of a smaller roller B, and is then carried forward upon the surface of the drying roller until it reaches the point C, by which time it is perfectly dry. The paper is then drawn away from the drying roller, and if it be of an inferior quality, such as the machine was producing when I saw it at work, the process of glazing is dispensed with, and the paper is rolled up in a finished state at D. In consequence of the paper being pressed upon the drying roller in a soft state, we may assume that it is brought into extremely close contact with the surface of the metal. It is in fact *caked* upon the drying roller, to which it in some measure adheres; and whether it be owing to this or some other cause, certain it is that when the paper separates from the roller, it is nearly as electrical as that which in the other machines undergoes the operation of glazing. It is here proper to explain that the paper, in this machine, immediately on its leaving the drying roller, rubs against an iron bar situated at C, and although the small degree of friction which takes place between this bar and the paper did not appear to me to be an adequate cause for so much electricity, I cannot undertake to assert that the excitation was not occasioned by the rubbing at this point.

In conclusion I have only to observe that the examination I have made of the circumstances under which the development of electricity takes place in the manufacture of paper, has been of too superficial a nature to enable me to form a decided opinion as to the cause by which the electricity is excited, and I wish it therefore to be understood that whatever I have suggested in the course of the foregoing observations, in the way of explanation of the effects I have described, must be regarded as mere conjecture, made for the purpose of stimulating curiosity, and leading to further enquiry. It is impossible to investigate the subject effectually in a paper mill without having a machine at command, and seriously deranging the routine of the process; but it would not be difficult to imitate on a small scale, the operations of drying and rolling the paper, and then, by varying the conditions of the apparatus, the cause which gives rise to the electricity might be ascertained with certainty.

W. G. Armstrong.

LXXVI. *Electricity without Contact of Elements.* By J. P. Gassiot, Esq., F.R.S., &c.

My dear Sir,—In the first Number of the Electrical Magazine, p. 57, there is described an experiment by Professor

Digitized by Google

Grove, wherein he proved that Volta's experiment of obtaining electricity by the mere *contact* of discs of copper and zinc is equally successful, if the contact is *prevented* by the interposition of a circle of card.—This experiment was originally made by him in the London Institution; and was exhibited by him on the evening of the 18th Jan. 1843.—(*Literary Gazette*, 21st Jan. 1843.)

It has, however, been objected to, that the experiment is far from being unexceptionable, particularly as it bears so strongly on the contact and chemical hypothesis of the voltaic pile;—that the mere interposition of a *rim* of paper might not have been sufficient to prevent actual metallic contact in that portion of the discs, which were not similarly protected; and also, that a certain amount of friction must have been produced by the pressure of the discs against the paper, and this in itself would be sufficient to account for the very slight signs of tension which were developed.

The following is a description of the means I have used to repeat the experiment, and you will find that these objections are entirely answered.

In the Philosophical Transactions for this year, I have described an electroscope by means of which the tension of a single pair of the voltaic battery is rendered distinctly appreciable.* Since its publication, it occurred to me that, by means of this instrument, I could repeat Mr. Grove's experiment without the objectionable points, to which I have referred; and, after a few trials, I found the following arrangement produced the effects I had anticipated.

Two plates, one of copper, and the other of zinc, four inches in diameter, were attached to the insulated glass pillars of my micrometer electrometer; (Philosophical Transactions, 1840, page 185) the plates were carefully approximated to about $\frac{1}{100}$ of an inch apart. When thus adjusted, two copper wires were attached to each of the plates, and also to the discs of the electroscope, which were found about $\frac{1}{8}$ of an inch apart; —the leaf of the electroscope is raised so as to allow it to swing clear of the two discs: and when not excited, it is equidistant from each;—thus arranged the apparatus is ready for the experiment.

With one hand, the experimenter holds a Zamboni's pile, so as to have one of its terminals within about an inch of the brass plate or cap of the electroscope, and with his other hand he separates the plates—immediately on the separation, the terminal of the Zamboni's pile is to be brought into con-

* One gold leaf suspended between two discs, which are respectively connected with the two terminals of the electrometer.—Ed.

Digitized by Google

tact with the cap of the electroscope, and the leaf will be *attracted* as follows.

When it is touched by — terminal of the pile to the zinc; —if by + terminal to the copper.—I am, my dear Sir,

Yours truly, JOHN P. GASSIOT.

Clapham Common, 24th Sept. 1844.

SCIENTIFIC MEETINGS.

ROYAL SOCIETY.

A description of an extensive series of the Water Battery, with an Account of some Experiments made in order to test the relation of the Electrical and the Chemical actions, which take place before and after completion of the Voltaic Circuit.—By J. P. GASSIOT, Esq., F.R.S.—Read Jan. 25, 1844. From the Phil. Trans. Part I. 1844, p. 39.

(ABSTRACT.)

THE last Number of the *Electrical Magazine** contains a short notice of this memoir. After alluding to his earlier experiments, made in the anticipation of obtaining a spark before completion of circuit, Mr. Gassiot says :—

"That I am justified in calling the spark, under such circumstances, an anticipated effect, may be fairly assumed, because every electrician is aware that the terminals of a voltaic series invariably evince a certain amount of tension; and as spark is but a consequence of tension exalted to a maximum it is only fair to anticipate that, by increasing the tension, it would be obtained."

The battery he employed in these researches is described in our last; and, in reference to the great pains he employed for insulating it, he adds :—

"With all the precautions I have described, the insulation of the battery was still imperfect; and, from the experience which I have gained during the construction of this apparatus, I have little hesitation in asserting, that the very nature of the water battery must prevent the experimentalist from obtaining insulation for any lengthened period, when such an extended series is employed."

He then introduces his experiments :—

"In proceeding to describe the effects which this apparatus has presented, I must endeavour to draw a distinct line of demarcation between the *static* and the *dynamic* effects; for although these are, in a certain sense, both associated in some forms of electric development, yet as I have been enabled in a degree to isolate them here, it is my intention to regard them separately.

"We know, from the very earliest experiments, that the extremities of a voltaic pile present opposite electrical states; it is, therefore, stating no new fact, to say that when one extremity of the series is connected with the ground, the other, on being connected with a gold-leaf electroscope, indicates a high degree of electric tension, and that the gold leaves diverge with considerable energy. Indeed, in the battery above described, there was little need of making connection with the ground; for, with all my precautions, I found the insulation was in a short time very imperfect, and that, by this communication with the earth, a complete circuit, to a certain extent, already existed.

* P. 380.

Digitized by Google

"As the *static* effects present themselves antecedently to the *dynamic*, they necessarily demand the first notice. The entire battery was connected in one series, and copper wires from the extreme cells were connected with the plates *a* and *b* of the double electroscope; this instantly produced a considerable and steady divergence of the gold leaves; and on applying the usual tests, the plate *b* connected with the copper extremity, gave signs of vitreous, and *a*, connected with the zinc, of resinous electricity. If *a* was connected with one extremity of the battery, and the other extremity was connected or not with the ground, the same general effects occurred; the divergence of the leaves corresponded with the connection, and the leaves of *b* diverged by induction; if, in this state, *b* was touched, and then removed from the influence of *a*, it was found charged with the opposite electricity.

"These inductive effects were obtained under other forms; for instance, the condensing plate, which had been removed during the preceding experiments, was opposed to the charged plate *a*. When *a* alone was connected with the battery, and *p* was touched while under the influence of induction, and then removed, *p* was found oppositely charged, as was also an insulated carrier ball, when similarly treated.

"The plate *a* of the electroscope being retained in connection with one end of the battery, a piece of very thin mica was laid on it; on this mica rested a wire W, proceeding from a single-leaf electroscope, the disc of which was in connection with the earth by means of a wire; with this arrangement the gold leaf was electrified by induction, and struck against the disc; glass, lac, and sulphur were in turn substituted for the mica, and the same general effects resulted. The same battery connection was maintained, the electroscope being disconnected. An insulated carrier ball was successively applied to the plate *a*, and an unlimited succession of charges could be carried and accumulated to another electroscope. These charges were with equal facility obtained when the *direct* connection between the battery and the earth was broken; the insulation of the battery was, however, comparatively imperfect, and I shall, therefore, have occasion to revert to some of these results, which I afterwards obtained less in degree, but equally definite in character, from a portion of the battery detached for the purpose of more efficient insulation. For the present we need only allude to those effects which do not absolutely involve the perfect insulations of the battery itself. When a Leyden jar, held in the hand, was subjected to the action of one end of the battery, a charge was readily accumulated, and, of course, still more favourably by means of a mica battery. When the coatings of a Leyden battery, consisting of twelve jars, with a surface of sixteen feet, were connected with the respective ends of the series, the accumulation of tension was considerable."

He then applies a delicate test to the battery while the circuit was closed, but found no trace of tension remaining. The inference to which he is led is thus expressed:—

"My first experiment, after making every allowance for loss of electricity, or, as it would be better to express it, loss of tension through insufficient insulation, admits but of one interpretation: the interpretation itself is generally allowed, but the force of it is not, I believe, generally admitted; it is, *that the elements constituting the voltaic battery, when arranged in series, assume polar tension before the circuit is completed*; and that in the apparatus above mentioned, this tension is such *that a spark will pass before the circuit is completed.*"

With the whole series in action, a continuous and brilliant succession of sparks were obtained between the discs of the electroscope; on one occasion they were continued uninterruptedly, day and night, for five weeks. Sparks could be drawn, at all times, (providing the operator were uninsulated,) from either end of the series; and this is the first point to be established, "that *tension* or *electro-static effects precede, and are independent of, the completion of the voltaic circuit.*" The author then continues:—

"Hitherto we have not obtained any insight into the condition of the *dynamic* effects, under such circumstances of antecedent tension. For testing the presence

Digitized by Google

of what is usually termed the current, or, in other words, obtaining the means of observing the electro-dynamic effects, I used the instrument which is best suited for examining such phenomena, and which invariably attests the instant completion of a voltaic circuit. An exceedingly delicate galvanometer was introduced, and the two condensing plates *a* and *b* of the double electroscope, were respectively attached by wires to the terminals N and P of the battery. If great care was taken not to make any connection with the ground, the party manipulating being himself well insulated on shell-lac, no action could be perceived on the needle in the galvanometer, although the gold leaves of the electroscope immediately diverged to a very considerable extent.

"This experiment was, however, of too much importance to be passed over without adopting every means of making it unexceptionable. Two trays from the battery, being a series of 160 cells, were removed and insulated, by being supported on stout varnished glass pillars twelve inches high; the whole being placed upon an ARNOTT's stove, in which a fire had been kept burning for several hours. The galvanometer was interposed between the zinc terminal of one tray and the copper terminal of the other; and the extremities of this reduced series were arranged so as to exhibit the same effects of electric tension which we have seen in the entire series, but not the slightest indication of dynamic action could be detected by the galvanometer."

Faraday's definition of "current," and the effects of magnetism dependent on it are given, and the consequences deduced from the experiments last cited are thus expressed:—

"Now it is manifest that, in the experiments already mentioned, the voltaic elements have the power of exhibiting electric effects at either, and both ends or terminals, before any progression or actual perceptible force takes place in the course of the series; in other words, that *static* effects exist before or independently of currents, but that these effects cease immediately on currents being developed."

And the author adds:—

"But, in an inquiry like this, we must examine more closely the actual chemical action, for it involves much of the source of controversy between the contact and chemical theories; and I was naturally anxious to discover whether simultaneously with these *static* effects, or perhaps antecedently to them, *any chemical action took place in the cells of the battery;* and if so, to what amount."

After alluding to electrolytic action, which Faraday had proved to be the representative of the quantity of current, he says:—

"There was every reason, with these facts before us, to expect that the battery, which did not produce a current, would not evince any degree of chemical decomposition. Recourse was, however, had to the test of experiment; and, instead of introducing the galvanometer, I substituted for it a small piece of bibulous paper, saturated with a solution of iodide of potassium; the gold leaves of the electroscope diverged as before, but however long the duration of action, not the least indication of the liberation of iodine was perceptible. The inference I make from this is that no definite chemical action took place in any cell of the battery, and consequently that the *electric effects* above shown, and which are termed *static* effects, take place *before* or *independently of the actual development of the chemical effects.*"

The author then gives several passages from the writings of Becquerel, De la Rive, Faraday, and Grove, in which this preparatory stage to current is recognised; but, he continues:—

"The question I am now examining is, however, not whether contact produces current, but whether it produces the electric development, and whether that development is accompanied by any chemical action; and this necessarily involves the question, whether the effects of current, or those usually called voltaic, have the same efficient cause as the electro-static. That certain effects can be produced in-

Digitized by Google

dependently of an *apparent* chemical action, is not merely proved by experiment with the water battery, but it is further confirmed by many unexceptionable experiments; among those for which I may particularly claim attention, are those of M. Peclet, who in describing them says, 'I have only had in view static electricity developed by contact; I have not troubled myself about currents when the circuit is closed.'*

"The examination of M. Peclet's experiments, the investigation of the action of the voltaic series generally, and more particularly of the water battery, seem to lead to the inference that electric affinity is greatly concerned in the *antecedent* action, of which chemical combinations, when the circuit is closed, are the *consequence*. I might quote the particular experiments of M. Peclet as an evidence of static effects having been obtained without any apparent chemical combination; but without attempting to follow out what may, perhaps, somewhat fairly, be assumed as hypothetical cases, viz., those in which tension does not appear to terminate in chemical action, *let us trace the process by which tension rises in an insulated pile, and the still further process necessary to establish a current.* Two trays of the battery were carefully insulated as before: if in this state one of the poles is touched by the hand, its electric tension is apparently destroyed, the leaves of the electroscope in connection collapsing; while those of an electroscope attached to the other terminal obtain their extreme divergence. If this battery be now left to itself, the end which has been touched regains a certain amount of tension, and the leaves of the other electroscope collapse in proportion: generally the means of raising the tension of one extremity of the battery is to touch the other. I do not mean to assert that the tension of the end which was touched is entirely destroyed, but certainly with 160 series, for the space of several seconds, I could not with the most delicate gold-leaf electroscope obtain the slightest indication of it.

"Marianini went through a series of experiments, in which he found that in no case was tension actually destroyed; but that it fell in proportion to the duration of the time during which the circuit had been completed. My object now was not, however, to complete the circuit; for I wished to test an intermediate stage between actual insulation and actual completion of circuit, in order to discover the character of the discharges effected by touching the respective terminals, or rather their influence over the state of tension, into which the whole series was thrown. I wished, for instance, to discover whether the discharge I effected, threw the elements of the battery *back*, into the normal condition which prevailed antecedent to the discharge, or whether it threw them *forward* by completing the act of chemical combination, the preparatory state of which already existed; whether, for instance, mere discharge, either by the earth or by the completion of the circuit, for an instant, is one small fraction of a current; and, if so, whether a current is not really a collection of discharges of electricity of tension.

"For this purpose the following experiments were made: a copper wire attached to N of the battery was connected with the galvanometer, and this with the plate *a* of the double electroscope. A platinum wire was attached to P of the battery, the end of which rested on a piece of bibulous paper saturated with a solution of iodide of potassium: another platinum wire, also resting on the paper, was connected with the other plate *b* of the electroscope; by the mechanical arrangement of this instrument, the plates could be approximated or separated as required.

"When the plates *a* and *b* were approximated so as to permit sparks to pass at intervals of about a second, a *tremulous* motion was imparted to the needle; but when they were brought so nearly in contact as to permit the discharges to take place in quick succession, the needle was *steadily* deflected, and iodine freely evolved; proving that chemical action was occurring in each cell, and that the current is a collection or accumulation of discharges of electricity of tension; for although the circuit was completed by distinct and separate discharges, still the deflection of the needle was as steady as if the discs had been in actual metallic contact.

"The discs *a* and *b* were then separated to the distance of about an inch; a piece of tinfoil was suspended by means of a thread of white silk; the tinfoil vibrated between the plates, but no effect could be produced on iodide of potassium or on the galvanometer."

* Archives de l'Electricité, vol. i. p. 622.

Digitized by Google

The next experiment was placing a piece of bibulous paper, charged with iodide of potassium, in connection, by means of a platinum wire, with one end of a perfectly insulated series of 320, while a corresponding platinum wire connected with the earth, rested on another part of the bibulous paper. Although this arrangement was continued for hours, no evolution of iodine occurred; but the instant the other end of the battery was uninsulated, that is to say, was placed in connection with the ground, so as to complete the circuit, electrolytic action was evidenced. The author continues:—

"I am aware of the many forms the contact theory has assumed since Volta first propounded it; nor can we lose sight of the many errors which his successors have committed in attempting to follow out their favourite views of metallic contact and electro-motive forces. I am indebted for much information on this point to the kindness and industry of Mr. C. V. Walker, who has occupied much time in procuring me references to the researches of those electricians already alluded to, as also to a long list of others whose names adorn the pages of science. I could easily have added to those I have named by referring to the experiments of many other authors who consider that their favourite theory of contact has been fully established. It is not, however, my object to advert to these speculations: we have before us certain facts connected with the action of the voltaic battery; first *contact*, or successive juxtaposition, and simultaneously with it, effects of *tension;* then the completion of the circuit, and simultaneously with it, *development of chemical action* and *current;* but in all these cases contact is first in order, developing tension. Becquerel describes it by stating, 'when two bodies are in contact the affinities commence exercising their action before combination takes place.' M. De la Rive, 'The electricity of tension developed by contact of heterogeneous bodies.' Faraday, 'That the particles of the electrolyte are brought into a polarized state, and raised to a certain degree of tension, before discharge takes place:' but I am not aware that there are any *experimental* facts to prove whether this tension in the voltaic battery, which itself is of an opposite character at each terminal, and, as we have seen, can be exalted so as to produce discharges in the form of sparks for many weeks' constant duration, is due to the chemical constituents of the battery, or to mere contact of dissimilar bodies, without reference to their chemical affinities. I was therefore most anxious to see whether some experiment could not be devised, which would test the action in a satisfactory manner, and for this purpose I availed myself of an extended series of Grove's gas battery, described by him in a paper already alluded to.*

"The elements used in this form of the voltaic battery consist of two gases and one metal; with fifty series charged with oxygen and hydrogen, it is stated that the gold-leaf electroscope was notably affected. Nothing can be more decisive than that the *static* effects of the voltaic battery are not due to the contact of dissimilar *metals;* as in this arrangement, only one metal, platinum, is used; but this battery, whose action is, in itself, so purely chemical, presents to us a full corroboration of the *static effects preceding the development of chemical action.*

"A series of forty cells, the same as are described in Mr. Grove's paper, were charged with oxygen and hydrogen; these sensibly affected the gold-leaf electroscope. This arrangement was kept charged for upwards of three months. No decrease in the gas of the oxygen tubes could be detected. Whenever the terminals were tested by the electroscope, they invariably exhibited the usual signs of tension; but not the slightest chemical or dynamic effect could be obtained until the entire circuit was completed."

The author now sought the minimum number of the oxy-hydrogen gas battery for producing static effects, and obtained them with as few as ten or twelve; forty of the oxy-nitrogen arrangement, (gases which do not combine,) did not affect the

* Vide *Elec. Mag.* No. 3. p. 193.

Digitized by Google

electroscope. Six pairs of the chlor-hydrogen; and two of the zinc and chlorine arrangement produced the effect. He then examines the connection between the energy of batteries and the amount of tension.

"Ten of the glass cells of the water battery were filled with dilute sulphuric acid. In each cell I placed a small porous earthenware vessel, also filled with the same solution. The metallic elements in this arrangement were amalgamated zinc and platinum; the latter being placed in the porous vessels, each cell was carefully insulated. This arrangement affected the leaves of the electroscope, while it required sixteen series of the water battery, to produce the same effect.

"The dilute acid was then removed from the porous vessels, and these were refilled with strong nitric acid forming the well-known nitric acid battery of Grove. Three series of this arrangement affected the electroscope, and with the assistance of a Zamboni's pile, *distinct signs of tension could be elicited from a single pair;* the platinum showing vitreous and the zinc resinous electricity.

"From the preceding experiments it appears, that to obtain evidence of tension, the principal requisite is good insulation, and that this condition being fulfilled, the most energetic chemical battery will exhibit signs of tension before the completion of the circuit with a smaller series than that which is merely excited with rain-water."

As the deductions with which the memoir concludes have been already presented to our readers,* we need not repeat them here. Besides having obtained signs of tension from the nitric acid battery, as reported in our last, Mr. Gassiot, alluding to the instrument then employed, says:—

"By means of this instrument, my friend, the Rev. Charles Pritchard, obtained signs of tension in a single cell excited by dilute sulphuric acid with platinum and zinc. This experiment I subsequently verified, and obtained similar results with single cells of other usual arrangements of the voltaic battery; but in all the experiments I made, the higher the chemical affinities of the elements used, the greater was the development of the evidence of tension."

REVIEWS AND NOTICES.

The Meteorology of Thunder-storms, with a History of the effects of Lightning on two hundred and ten Ships of the British Navy, &c. By W. Snow Harris, Esq., F.R.S. Reprinted from the *Nautical Magazine*, 8vo. pp. 66.

Mr. Harris has very patiently hunted through the log-books of our Navy, and has thus rescued from comparative oblivion, and presented in a mass the effects of Lightning upon our ships; he has shown how great the loss has been to our country from this cause. The History opens with a review of the Phenomena of Thunder-storms, in which are given several deductions arising from the facts put forth. We may refer to this hereafter. For the present, we thank Mr. Harris for the labour he has imposed on himself, in order to furnish to science this valuable contribution.

* Vide *Elec. Mag.* No. 5. p. 380-1.

Digitized by Google

A Manual of Electro-Metallurgy. By GEORGE SHAW. Second Edition. London: Simpkin & Co. 1844. 8vo. pp. 202.

THIS new edition is virtually a new book: it contains all the prominent features of the electrolysis of metallic solutions; the author has, he says, "sought to make the work as brief as possible, by the omissions of some of the minute details of manipulation." However, the reader will find abundance of information on all points. The author has evidently an experimental knowledge of the art on which he writes.

NEW BOOKS.

Manual of Electro-Metallurgy, George Shaw, Second Edition, 7s. 6d.—Meteorology of Thunder-storms, W. Snow Harris, F.R.S. —Electrotype Manipulation, Part I. Charles V. Walker, Fourteenth Edition. — Illustrations of the Climate of Glasgow, J. P. Nichol, LL.D., 16s.—Kaemtz's Complete Course of Meteorology, English Translation, with Notes. Charles V. Walker.—Note sur la Position des poles Magnetiques de la Terre, par M. L. J. Duperrey.—Lettre de M. Duperrey à M. Quetelet, au sujet des observations sur les intensités relatives du magnetism terrestre à Paris et à Bruxelles.—Annuaire magnetique et Météorologique du corps des ingénieurs des Mines de Russie, par M. A. J. Kupffer, Année 1840. *St. Petersburg,* 1842, 1 *vol.* 4*to.* — *Annalen für Meteorologie und Erdmagnatismus. Jahrgong,* 1842, 2*tes und* 3*tes heft. Munchen,* 1842, 2 *brochures,* 8*vo.—On the determination of the Intensity of the Earth's Magnetic force in Absolute Measure, Rev. H. Lloyd, Dublin,* 1843, 4*to.—Statisque Appliquée au Magnetism.—Note sur la manière de corriger le defaut de centrage des boussoles d'inclination. M. E. Bary,* ½ *sheet, in* 8*vo. —Le Leggi del Magnetismo nel Filo congiuntivo percorso dalla Corrente Voltiana; by F. Zantedeschi. Venice,* 1843.— *Traité des Phénomènes Electro-physiologiques des Animaux. Par Prof. C. Matteucci; avec Etudes Anatomiques de la Torpille, Par Paul Savi.—Paris,* 1844.—*Archives de l'Electricité, No. XIV. July* 30, 1844.—*Sur la Relation qui existe entre le sens du courant électrique et les contractions musculaires, dues à ce courant, par MM. Matteucci et Longet. Paris, Sept.* 9, 1844.

NOTICES OF EXPERIMENTS, &c.

Difference of Longitude determined by Morse's Telegraph.—Among the many wonderful developments of the new Telegraph, one has just come to light which will be regarded in the world of science as deeply interesting. Professor Morse suggested to the distinguished Arago, in 1839, that the Electro-Magnetic Telegraph would be the means of determining the *difference of longitude* between

Digitized by Google

places with an accuracy hitherto unattained. By the following letter from Captain Charles Wilkes to Professor Morse, it will be perceived that the first experiment of the kind of which we have any knowledge has resulted in the fulfilment of the Professor's prediction.

Washington, June 13, 1844.—My Dear Sir: The interesting experiments for obtaining the difference of longitude through your Magnetic Telegraph were finished yesterday, and have proved very satisfactory. They resulted in placing the Battle Monument Square, Baltimore, 1m. 34sec. ·868 east of the Capitol.

The time of the two places was carefully obtained by transit observations. Lieutenants Carr and Eld assisted me in these observations. The latter was engaged in those at Baltimore. The comparisons were made through chronometers and without any difficulty. They were had in three days, and their accuracy proved in the intervals marked and recorded at both places. I have adopted the results of the last day's observations and comparisons, from the elapsed time having been less.

The difference from former results found in the American Almanac is ·732 of a second. After these experiments I am well satisfied that your Telegraph offers the means for determining *meridian distances* more accurately than was before within the power of instruments and observers.

Accept my thanks and those of Lieut. Eld for yourself and Mr. Vail, for your kindness and attentions in affording us the facilities to obtain these results. With great respect and esteem, your friend, Charles Wilkes. Prof. S. F. B. Morse, *Capitol, Washington.*—*From the Washington National Intelligencer of* 21 *June*, 1844.

Decomposition of Nitrogen.—"M. Schönbein, professor of Natural Philosophy at Basle, has just decomposed nitrogen into ozone and hydrogen. Ozone is a simple halogen body, analogous to chlorine, iodine, bromine; and nitrogen is a combination, analogous to hydrochloric acid. M. Schönbein will, ere long, make known the process by which he has arrived at so remarkable a result."—*Constitutionnel Neuchatelois*, 13 June, 1844.

Telegraph with the Hydro-electric Machine.—A Patent for the application of this machine to telegraphing has been secured by the Rev. W. Highton, of Rugby.

"*A Magnetic Telegraph*—is now in full operation between the cities of Washington and Baltimore. The following examples will show the manner in which this instrument annihilates both time and space:—'On Saturday morning the batteries were charged, and the regular transmission of intelligence between Washington and Baltimore commenced, as we learn from the *Baltimore Patriot.* A large number of gentlemen were present to see the operations. At half-past 12 o'clock, the following was sent to Washington:—'Ask a reporter in Congress to send a despatch to the *Baltimore Patriot*, at 2 o'clock P.M.' In about a minute the answer came back thus—'It will be attended to.' 2 P.M.—The despatch has arrived, and it is as follows:—1 o'clock—There has just been a

Digitized by Google

motion in the house to go into committee of the whole on the Oregon territory. Rejected. Ayes 79; Noes 86.' 'Half-past 1 o'clock.—The house is now engaged on private bills.'—Quarter to 2 o'clock—Mr. Atherton is now speaking in the senate. Mr. S. will not be in Baltimore to-night.' So that Baltimore papers are thus enabled to give their readers information from Washington up to the very hour of going to press. This is indeed, the annihilation of space."—*New York Daily Sun.* [The distance between Baltimore and Washington is 34 miles].—*Times.*

Wheatstone's Electro-Chronoscopes.—We have seen the arrangements for determining the velocity of falling bodies and projectiles, as alluded to in our last (p. 399.) The apparatus consists, 1st, of a chronoscope, or time-measurer:—this is very simple in structure, being a few wheels regulated by an escapement, and having as a moving power a weight, so adjusted as to communicate regular motion to the system, during the whole of the brief time it is allowed to fall; an index and dial are added. 2nd, of a means of putting this mechanism into action, when the body under examination begins to move, and stopping it when the body reaches its destination. *For falling bodies.*—At the back of the chronoscope is a small electro-magnet, the keeper of which is so contrived that, when it is in contact with the magnet, an attached pin acts as a detent to the clock mechanism; and during the time the keeper is not in contact, the chronoscope marks time. The falling body (a bullet) is so suspended on an arm projecting from a tall rod, that it can readily be detached by pulling a thread; in this condition, it presses against two pieces of metal and so completes the circuit. The circuit contains the magnet, a voltaic battery, the bullet and a *Rheostat**, of which so much wire is included in the circuit, that the electro-magnet is *just* able to sustain the keeper, and hence will part with it, assisted by a spring, the instant the bullet is set free. Immediately beneath the bullet, are two pieces of board hinged together; when they are slightly opened, like a book, a metal connection at their edge is separated and the circuit is broken; but when they close, which they do by the weight of the fallen bullet, the circuit is completed. This circuit contains the magnet, the voltaic battery, and the metal of the boards,—but not the rheostat, because in this case it is desirable to give the magnet as much power as possible; so as instantly to arrest the keeper, and stop the train. The action is obvious; when the bullet is set free, the current ceases, the keeper is liberated, and the record of time begins; when it reaches its destination, the current again comes into play, the keeper is attracted and the time-keeper is stopped. The number of seconds read off on the dial, measures the time occupied by the body in falling through the given distance.—*For projectiles.*—An ivory ring, placed over the nozzle of the gun, sustains a thin wire, by which the circuit is completed: the ball, in leaving the gun, breaks this wire, and, as before, sets the chrono-

* Vide fig. Elec. Mag. No. 5, p. 385.

Digitized by Google

scope in motion. The ball is directed against a hinged target, similar to the boards already described, and the circuit is again complete, and the instrument stopped. The other arrangements are the same as for falling bodies.—Ed. Elec. Mag.

Atmospheric Electrical Apparatus at the Royal Observatory.—"In the autumn of last year, I had an opportunity of examining the beautiful arrangements of the atmospheric electrometer at the Kew Observatory,* which have been made under the superintendence of Professor Wheatstone and Francis Ronalds, Esq. It was impossible to see these without perceiving that considerable improvements might be made in our own, by following the same plan with such alterations as the difference of local circumstances rendered necessary. The form which I have adopted may be generally described as follows. Two iron rods are extended from the top of the mast to the ground, and are kept in a state of tension by weights hung in a pit. These rods serve as guides to a travelling frame, which carries a copper rod supported on a glass cone. A lamp is placed below the glass cone to keep it warm and dry; and another lamp is attached to the top of the copper rod to collect atmospheric electricity. The frame is lowered twice every day for trimming the lamp, and is then raised again; this operation is effected with a windlass and rope. The wire by which the electricity is conducted from the copper rod to the electrometers within the building is kept in tension by a lever with a weight at one end, which also serves for the electric conduction. During the operation of lowering or raising the frame, a self-acting reel (driven by a weight,) coils up or delivers the wire which is then detached from the lever. The metallic apparatus within the building is supported by a glass rod, whose ends are maintained in a state of warmth and dryness by small lamps. The electrometers are the dry pile apparatus, (mentioned in the report of last year) three expansion electrometers, and one Henley's electrometer; there is also an apparatus for measuring the length of sparks. Judging from the long time through which the apparatus will preserve a trifling charge of atmospheric electricity, I conceive that its insulation is nearly perfect; yet, from some unknown cause, (not improbably the proximity of lofty trees) the indications are much less constant than those at the Kew Observatory. The galvanometer seems to be affected not more than once or twice in a year. The induction copper ball gives no certain results."—*The Astronomer Royal's Report to the Board of Visitors*, June 1, 1844.

Electro-Physiology.—We have had the opportunity of being an eye-witness to Prof. Matteucci's experiments on the electric action co-existent with the chemical phenomona of animal life. The inner or wounded surface of a muscle is shewn to act as the zinc of a pile in developing a current. These experiments were witnessed by several of our eminent Electricians and Physiologists in the Laboratory of King's College; Prof. Matteucci's discoveries and deductions will be given in our next.—Sep. 23, 1844.

* Vide *Elec. Mag.* No. 3, p. 213.

Digitized by Google

ELECTRICAL MAGAZINE.

JANUARY, 1845.

LXXVII. *On the Instruments employed in Electro-physiological Researches.* By Professor C. MATTEUCCI. Being Chap. II. of his "Treatise on the Electro-Physiological Phenomena of Animals."

(TRANSLATION.)

I MIGHT have been able to suppress this part of my work, had not my principal object been to write it, in order to place physiologists in the condition of being able to investigate the subject of animal electricity. Physics, like all natural science, has in these latter days acquired so great a development, that it is no longer granted to a single individual to occupy himself at once with the different parts of which it is composed. It will not, therefore, be without advantage to the reader, if I commence by familiarizing him with the instruments employed in electro-physiology. I shall particularly insist upon the galvanometer, which is of more general use.

When a wire, traversed by an electric current, is brought near a compass needle and parallel with it, the latter is seen to deviate from its position; and, after a certain number of oscillations, to stop, making a certain angle with its primitive position. The angle at which the needle stops, is always less than that resulting from its first motion. The direction of the deviation, the relative position of the needle and the current, and the size of the permanent angle of deviation, are the elements that are found associated in the law of the electro-magnetic action discovered by Oersted. If the conducting wire is above the needle, its austral pole is directed toward the west, when the

Digitized by Google

current traverses from the south to the north, in the position of the wire parallel and near to the needle; on the contrary, the deviation of the austral pole is to the east, if the direction of the current is from the north to the south. Every thing occurs in inverse order, if the conducting wire of the current is below the needle; it is very easily perceived by this that if the needle is between two currents, the one above and the other below, and quite parallel, it will not experience any movement, when the direction of the two currents is the same. On the contrary, its deviation will be double, and the effect of the two currents will be added, when the direction of the two currents is opposite. A circular or polygonal current, therefore, acts by all its points to make the needle, around which it circulates, deviate in the same direction. If, instead of a single current, or rectangular wire in which the current circulates, two are taken, parallel to each other, in which a current of the same intensity moves in the same direction, the deviation of the needle will be doubled; and, in general, the deviation will augment with the number of circuits that the current traverses, preserving in all the same intensity. It is scarcely necessary to mention that these circuits must be separated from each other by a substance which does not conduct the current, in order to prevent the currents passing from one circuit into the other.

The construction, therefore, of a galvanometer is very simple, and its use very easy to conceive. A copper wire is taken, covered with silk, and it is rolled several times round a frame of wood or of very pure copper; a magnetic needle is suspended in the interior of the frame, which is so arranged in the magnetic meridian that the plane of the axis of the needle is parallel to the different circuits by which it is surrounded.. The two extremities of the wire are connected with the two poles or extremities of the electro-motive element. The needle moves over a graduated scale, the zero of which is in the same plane with the needle.

For electro-physiological experiments the galvanometer is better in proportion as its wire makes more convolutions around the needle; they are now constructed with 3000 convolutions. The wire is only the sixth of a millimetre (.023 in.) in diameter, and it is formed of very pure copper.

Nobili was the first who devised the astatic system instead of a simple needle, which has much increased the sensibility of the galvanometer. For this purpose two magnetic needles are taken, which must be as nearly identical as possible with respect to their dimensions, their degree of temper, and their magnetization; these two needles are fixed in a

Digitized by Google

very slight brass stem, or in a straw, exactly in the same plane and with their converse poles opposite to each other. One of the needles is placed in the interior of the frame, and the other outside and above its upper side. The whole astatic system is suspended to a filament from a cocoon. If it were possible to make two needles exactly equal in their degree of magnetization, the astatic system, composed of two needles, would undoubtedly be altogether insensible to the magnetic action of the earth, which is always contending against the current, in order to bring back the needle to zero. The galvanometer constructed with this system would necessarily present the greatest possible degree of sensibility; that is to say, the most feeble current would produce a very great deviation. But it may easily be imagined that, with such an instrument, we could never compare together currents of different intensities. The system would be in equilibrio in all positions; and when once deviated it would not return to zero when the current should have ceased to act. And as an experiment must always be commenced with the needle at the zero of the scale, it would be impossible to change the position of the frame every time. We must, therefore, leave to the astatic system a small portion of magnetic force, in order to give it direction, which is accomplished by taking one of the needles somewhat more magnetic than the other. In galvanometers of perfect construction, there is attached a very simple mechanism, by which a certain rotatory motion is given to the former, by means of which the upper needle is always brought back exactly to the zero of the scale.

We may always judge of the sensibility of a galvanometer by the slowness of the oscillations of its magnetic system; the galvanometer is in possession of sufficient sensibility when its system makes one oscillation in a minute.

It often happens that the sensibility of a galvanometer is manifestly reduced, after a certain time; too strong a current that has been sent through the galvanometer,—the presence of some magnetic bar too near the galvanometer,—the reaction of the magnetism of the two needles,—the difference in their dimensions and in the quality of their steel,—are sufficient causes to alter the astatic system. It is well to know how, of one's self, to restore the galvanometer to its primitive sensibility. The first operation is to make the system oscillate, at the same time consulting a seconds-watch in order to know the duration of an oscillation; and then, by taking away in the first instance the upper needle, and in the next the lower, we are easily enabled to judge which is the weaker of the two. If the system remains in its position, when one of the needles

Digitized by Google

has been taken away, we are sure that the needle taken away was more feeble than the other; on the contrary, if the needle which remains returns of itself, it is demonstrated that the needle taken away was the stronger. The more feeble needle is then placed on a table where it is held by the pressure of the finger, and a small bar magnet is passed along it in a parallel direction from end to end. The motion of this bar must never be arrested or returned on itself; when arrived at the end of its course, the bar is raised and carried back to the first point whence it started, and a second course is made. The pole of the needle opposite to which the course of the bar was commenced, will be of the same name as the opposed pole of the bar. If we desire to reduce the magnetism of the needle, the arrangement of the two poles would be precisely contrary. After a few courses, the number of which varies according to the power of the bar, the dimensions of the needle, and the magnetism it has lost, the needle is returned to the system, and the duration of the oscillation is determined. If the duration has become greater, we are sure that the system, and consequently the galvanometer itself have gained sensibility. On fixing the needles in their place, great care must be taken to place them exactly in the same plane. To succeed in these operations, it is necessary to possess much patience, and to have acquired practical skill; it is no uncommon thing to pass entire days in well arranging one's galvanometer. It often happens that too much magnetism is given to the needle; and then in the operation of taking it away, the object is not always attained in the first attempt.

M. Rumkorf, of Paris, a skilful and intelligent maker of all electro-magnetic instruments, has devised a little apparatus, by means of which different degrees of sensibility may be given to the galvanometer, by rendering the magnetic system more or less astatic. For this purpose, he takes two small magnetic bars, of about 8 cent. (3 in.) in length, movable round an axis situated in the centre of an arc of a divided circle, the poles of the opposite names facing each other. When the two bars are vertical, their action is nothing upon all points situated beneath, whatever may be their distance. This little apparatus is placed above the galvanometer on the upper plane of its glass shade, in such a manner that, when the bars are vertical, their line of junction coincides with the axis of suspension and the plane of the two needles; it is so arranged that the poles of the two bars of the *compensator* are facing the poles of the contrary name; or, as the case may be, the poles of the same name of the upper needle. By

Digitized by Google

separating the two bars to a greater or less distance, the sensibility of the galvanometer is proportionately increased.

Generally speaking, the maker of a galvanometer takes care to write on the scale an indication by which we are enabled to know immediately from the direction of the deviation of the needle, the direction of the current. For this purpose, we find the two letters A and B marked on the scale; the same two letters are marked on the side of the two extremities of the galvanometer; by means of a first experiment we may determine, once for all, whether the point on the head of the needle is carried toward A or B, according as the current enters into the wire of the galvanometer by the extremity A or B; namely, according as the positive pole of the battery communicates with A or B. It is scarcely necessary to mention that, if it is a single electro-motive element, zinc and copper, for example, which is connected with the wire of the galvanometer, the current will be directed from the copper to the zinc in this wire.

It is always advisable, before commencing a series of experiments, to satisfy ourself that the indication written on the galvanometer is correct, in order not to be deceived as to the direction of the current. This precaution is especially necessary, after having arranged our magnetic system. The matter is very easily accomplished; a platinum wire is twisted to one of the two ends of the galvanometer wire, and the two extremities, platinum and copper, are plunged into distilled or spring water. If the galvanometer is very sensible, there will be a deviation of some magnitude, due to a current, the direction of which, in the galvanometer, is from the platinum to the copper, and consequently, from the copper to the platinum in the liquid.

We are well aware, that the deviations of the needle of the galvanometer are not proportional to the intensities of the currents, except for angles comprised between 0° and 20° or 30° at most. Beyond this number, the intensity of the current, in order to produce a given deviation, must be much greater according as this deviation rises to higher degrees. I shall not stop to describe the different processes which have been given, in order to obtain tables of proportion. In the experiments that we shall have occasion to relate, we shall not obtain without difficulty any numbers higher than 30°; and, in all cases, we shall content ourselves with comparing together the intensities of different currents, measured by the deviations, without tracing them to the forces to which they are due.

When experiments are made with the galvanometer, it is necessary to have this instrument placed on a firm surface.

Digitized by Google

For this purpose, a marble or a wooden slab should be fixed in the wall. Care must likewise be taken not to come near the galvanometer with any piece of iron or steel.

Another instrument, which may be very advantageously employed in electro-physiological researches, is presented to us by the frog when properly prepared. For this purpose, we must select one of the most lively frogs, and begin by preparing it according to Galvani's plan: about two-thirds of the body of the frog is to be cut off just below its fore-paws, the head and the entrails are cast aside, and the two-thirds of the frog, which has been preserved, is skinned. We thus obtain a piece of the spinal cord, with the pelvis, and the two hind legs. Finally, by introducing the scissors between the lumbar nerves and the pelvis, and cutting the latter in two places, we succeed in obtaining the frog, as it is usually called, *prepared after Galvani's plan.* In order to employ the frog in the study of the electric current, the latter must be passed along the nervous filament alone of the frog. For this, the frog prepared after Galvani's plan is cut in half; and, by a very easy preparation, we are enabled to remove from the half frog the bone and the muscles of the thigh, preserving its nerve untouched. In this manner, we end by having a frog's leg, to which is attached a long nervous filament, composed of the lumbar portion of the pelvis and the crural portion of the thigh. We have nothing further to do than to introduce this leg into a varnished glass tube, in order to have an instrument very sensible to the passage of the electric current. To employ this kind of galvanoscope, the glass tube is taken by the end opposite to that into which the leg of the frog has been introduced, and the nervous filament, which is hanging outside the tube, is made to touch the two points of the electro-motive element that we desire to study. When the nervous filament is traversed by an electric current, the leg is seen instantly to contract. If there were any reason to fear that the direct contact of the nerve with the points of the electro-motive element might irritate it, independently of the electric current, we have merely to place on the two points of the electro-motive element two slips of paper moistened with water, and then to close the circuit by touching the two slips with the nervous filament.

The frog employed in this manner, which I shall henceforth term *the galvanoscopic frog*, is certainly the most sensible apparatus that we possess, if it is renewed from time to time. This instrument is, moreover, very exact in its indications, if we take care to expose the nerve well, and to close the circuit with the nerve alone, without ever including any portion of the muscle of the leg. The galvanoscopic frog not

Digitized by Google

only indicates to us the existence of the electric current, but it may also serve us with a great degree of probability in determining the direction of the current. When the frog is a little weakened, we almost always perceive the leg contract, when the circuit is closed, and this limb remain motionless, when the circuit is opened, if the current is directed in the nerve from the nerve toward the leg. When these phenomena take place in the opposite direction, it is because the current is directed from the leg towards the nerve. We have, therefore, only to close the circuit with the nerve of the galvanoscopic frog, and to open it the instant afterwards, in order to establish in which of the two instants contraction took place. To confirm the indication of the first experiment, the position of the nerve of the galvanoscopic frog is reversed, —if the first indication were exact, the leg ought to contract in the latter case, when it remained tranquil in the former.

It may happen in electro-physiological experiments, that we desire to examine for the existence of electricity of tension. I shall say but two words on the electroscope, which may be employed with the greatest advantage. It is a bell-glass varnished throughout its upper part, and furnished with a hole at its centre, by which is introduced a brass rod, fixed to the hole with mastic. The end of the rod that rises outside the bell, is terminated by a small brass ball: on the other end is stuck a very narrow slip of gold leaf, five or six centimetres long. The bell, which is open at its lower part, rests on a wooden base, in which are fixed perpendicularly, and opposite to each other, two dry piles, arranged so as to be in connection at their base, and to have poles of contrary names upward. The gold leaf is thus suspended between two contrary poles, and remains in equilibrio by the equal and contrary action to which it is subjected. Scarcely is the leaf electrized, when it moves toward the pole of one of the piles, which has electricity contrary to its own. This electroscope is extremely sensible, and very easy to manage. We have only to notice which of the piles the gold leaf approaches, in order to know immediately the nature of its electricity.

If we require a still more delicate electroscope, we have only to connect a voltaic condenser with the bell of the electroscope that I have described.

Finally, we are desirous in electro-physiological experiments to have recourse to an electric current of a certain intensity and a constant force. The pile to be employed for the purpose might be composed as usual of plates of zinc and copper; the copper plate must be plunged into a solution of sulphate of copper contained in a glass vessel; a kind of leather bag filled

Digitized by Google

with a solution of common salt, or water acidulated with sulphuric acid, must be placed in this liquid. The zinc plate is immersed in the bag; and it is advisable to employ it, after having amalgamated it, which is easily managed by rubbing it with a little mercury and acidulated water.

To be sure of the constancy of the current obtained with this pile, it is well to have a *tangent compass.* This apparatus is composed of a large circle, four or five decimetres in diameter, formed of a copper ribbon five millimetres wide and two thick. This ribbon is covered with silk; and its extremities being conveniently bent, are each plunged separately into a cup containing mercury. At the centre of the circle is suspended a very small magnetic needle, which turns above a scale: the circle finally is placed in the plane of the magnetic meridian. The intensity of the current is measured by the tangent of the angle of deviation. [A.]

LXXVIII. *On the Method to be followed in Applying the Galvanometer to the Study of Electro-Physiological Phenomena.* By Prof. C. MATTEUCCI. Being Chap. III. of his "Treatise on the Electro-Physiological Phenomena of Animals."

(TRANSLATION.)

WHENEVER we wish to make use of the galvanometer, the two extremities of the metal wire that is rolled round the frame are attached to two points of any electro-motive element, between which the discharge of the two electricities is to take place. Thus, in the simplest case of the voltaic pair, one of the metals of the pair is connected with one of the extremities of the galvanometer, and the other metal with the other extremity. The two metals are then plunged into any liquid conductor, and the deviation of the needle immediately takes place. This deviation, which is first made by a motion of impulse, drives the needle so that it makes a greater angle than that in which it finally rests, after a few oscillations. In a great number of phenomena we are obliged to take the first deviation of the needle to measure in some manner the intensity of the current, and then to compare it with other currents, in like manner measured by their primitive deviation.

When the current is developed by the chemical action of two solutions, the experiment must be arranged in a particular manner. Suppose that we wish to discover whether the action

Digitized by Google

of an acid or an alkali produces an electric current. For this purpose we take two platinum capsules filled with distilled water, each of which is in communication with the extremities of a galvanometer having a long wire. By means of a lock of cotton saturated with the same water, the two capsules are connected together. We will suppose that the needle remains at zero at the moment when the lock of cotton is introduced, and the two liquids are thus placed in connection. In the opposite case the needle will not be long in returning to zero. If we then touch the middle or thereabouts of the lock with two glass tubes, of which one has been plunged into an acid, and the other into an alkaline solution, the needle will be seen to deviate—thus indicating that an electric current has been produced, which is directed in the lock of cotton from the alkali to the acid. If the two drops, one acid and the other alkaline, that are deposited on the lock, are not quite beside each other, it will be some moments before the deviation will appear; it will then gradually augment to the point at which it had arrived in the former case.

In describing this experiment we have said that it may happen, on introducing the lock of cotton between the two capsules, that some movement of the needle may take place; and that, in this case, we must wait until the needle has returned to zero. These movements in the needle, which always indicate the passage of an electric current, are of the same nature as those which are observed when the two platinum plates that are attached to the two extremities of the galvanometer are plunged into water. In making this experiment, even though employing plates of platinum as identical as possible, it is very rarely that there is no sign of an electric current. We have already said that if, after having closed the circuit with the lock of cotton, we wait for a few moments, we shall see the needle return to zero. By this we see that if the lock of cotton is prepared with the two drops of acid and alkali before commencing the experiment, and the experiment is then made, by touching at the same time the two platinum capsules with the extremities of the galvanometer, and making them communicate together by means of the lock, the deviation that will be obtained will be due to a compound effect, partly from the current developed by the chemical action of the acid on the alkali, and partly from the current developed by the mere plates of platinum when plunged into the liquid of the capsules. These currents may sometimes exalt and at other times destroy each other. It follows from this, that in the use of the galvanometer we must always be on our guard against the current that is developed by its two extremities,

Digitized by Google

independently of that of the electro-motive element, which we propose to study. Unless we do this, we shall obtain erroneous results, which will arise from the manner of experimenting.

In all electro-physiological experiments, we touch with the extremities of the galvanometer animal parts composed of solid bodies, or saline solutions of a greater or less degree of neutrality. These solutions may act chemically, and in an unequal manner, on the metallic extremities of the galvanometer. Being endowed with a certain power of conducting electricity, these same solutions may conduct the electric current, of which we have seen the developement, even through the extremities of the galvanometer, independently of the chemical action of the liquid in which they are plunged. An electro-physiological experiment, therefore, will never be exact, if we do not assure ourselves before-hand that none of the currents of which we have now spoken can be produced and be made apparent by the galvanometer.

In order to obtain this object, the first condition to be satisfied is to form the extremities of the galvanometer with the same metal. We must also choose, among all metals, that which is least likely to be attacked by water and by saline solutions; for without this, even though the extremities of the galvanometer should be of the same metal, very strong currents would always be obtained, and the more so as the conductibility of the liquid might be greater.

This happens with plates of silver, copper, or iron. With a very sensible galvanometer, very strong currents are obtained by plunging similar plates of these metals into water scarcely salt, or even into distilled water. It is sufficient if one of these plates be a little more polished than the other—if one be warmer than the other—if one be immersed after the other—in order to have in all cases very great deviation, which it is almost impossible entirely to destroy.

The metal which must be chosen for constructing the extremities of the galvanometer is, therefore, platinum. For this purpose two plates of platinum, 5 or 6 millimetres wide ($\frac{1}{5}$ in.) are taken, and are each fixed with a handle of wood or bone. The extremities of the galvanometer wire are soldered to these two plates, and then the whole of the handle and the plate are covered with a coating of sealing-wax varnish, so as only to leave the extremity of the plate disclosed for a length of 5 or 6 millimetres. We then obtain for the extremities of the galvanometer two platinum plates with an equal surface. We must not on this account imagine that nothing more is to be feared in the experiment. Indeed, if two plates, such as I

Digitized by Google

have described them, are plunged into water scarcely salt, or even into distilled water, we shall always obtain, with a very sensible galvanometer, deviations that sometimes amount to 10°, 15°, and 20°. It is a difficult matter to assign before-hand the direction of the current, inasmuch as we are not in all cases perfectly acquainted with its origin. The currents thus obtained would be much more powerful if the liquid employed were salt or acidulated water. We are acquainted with a certain number of circumstances in which we can anticipate the direction of the current, obtained while operating in the manner described above. These circumstances must be studied with much care.

Suppose that I have plunged the two platinum plates of the galvanometer in distilled water, and that I have waited a few minutes; after this time the needle generally returns to zero. I then remove one of the plates from the liquid, and leave it thus for a few seconds, and I then again immerse it with the other, which had not been removed. We are sure to perceive the needle deviate, and the deviation will be in proportion to the sensibility of the galvanometer; and with the same instrument it will vary with the conductibility of the liquid, the duration of the separation of the two plates, and with their extent. This current has a constant direction, namely, it always passes in the liquid from the plate which has been removed to that which has remained all the time in the liquid. The current obtained in the experiment that I have described will be still stronger, if the plate which is removed from the liquid be wiped with any body whatever; and even stronger still, if it is heated: its direction does not vary. I have tried this experiment by employing, instead of distilled water, aqueous solutions of copper, potash, ammonia, water acidulated with sulphuric or nitric acid, or water to which the serum of blood or milk had been added. In all cases the current obtained has been determined in the same direction, namely, from the plate removed from the liquid to the other.

In all electro-physiological experiments, therefore, we must faithfully attend to the following rules:—We must employ, for the extremities of the galvanometer, two platinum plates having an equal extent of surface, and constantly the same; and we must touch the animal parts in which we seek the electric current with both plates at the same time. With a little practice all these rules are very easily followed, by employing two plates prepared as I have described them. The two handles are held in each hand, and the method of bringing them both at the same time into contact with any body is easily acquired.

Digitized by Google

Let us now return to the phenomena from which we have wandered, namely, to the current that is obtained on plunging into water the two plates of the galvanometer, when made of platinum, and prepared in the manner I have indicated. If, before plunging the two plates at the same time into water, one of them is moistened in an acid solution, and is then plunged with the other into the water, we are certain of obtaining a deviation amounting to as much as 30° or 40°, according to the sensibility of the galvanometer and the density of the acid solution. The experiment succeeds by employing acetic acid for acidulating the water, which is one of the most feeble acids known to the chemist. By employing sulphuric, phosphoric, or hydrochloric acid, I have always found the same direction in the current. The current passes in the liquid from the plate that had been plunged in the acid to the other plate. We must not confound this mode of operating with that described in the Memoirs of MM. Becquerel and Nobili, which gives different results. If, instead of acidulated water, we employ a solution of potash or ammonia for moistening the plates, a very strong current is also obtained, which is directed like the preceding, namely, from the plate moistened by the alkali to the other. I should observe, that if the acid solutions employed in these experiments are ever so little saturated, we shall fall into very great anomalies in the direction of the current that is obtained. The only manner of obtaining the most constant results possible is to be sure before-hand that there is no current on plunging the two plates into water.

A liquid that I was interested in examining in these experiments, instead of acidulated or alkaline water, was blood and its serum.

I took human blood, the coagulation of which had been prevented by shaking it, as soon as it was drawn out from the vein. I commenced by assuring myself that the two plates of the galvanometer, when plunged at the same time into distilled water, gave no current. (We shall presently see how we manage to know this.) I then removed the two plates from the water, and at the same moment I immersed one in blood and the other in water similar to that in which both the plates had been. Some seconds afterwards I removed the two plates, one from the blood, the other from the water, and I plunged them together into water. Immediately I obtained in the galvanometer a remarkable deviation, due to a current passing in the liquid from the plate moistened with blood to the other plate. I wished to vary the experiment, in order to place myself as nearly as possible in the same condition as I might occupy when making experiments on animal electricity.

Digitized by Google

For this purpose I took a lock of cotton 5 or 6 cent. (2 in.) long, of which I saturated one-half with distilled water, and the other with blood taken from a pigeon, which had been agitated to prevent coagulation. I employed the lock thus prepared to form an arc of communication between two capsules, one of which was filled with distilled water, the other with the same pigeon's blood. Finally, I closed the circuit with the two plates of the galvanometer, which gave no current when plunged into water. I obtained a current amounting to 12° of my galvanometer, always directed in the lock from the blood to the water. I continued for three days to reverse these experiments from time to time, and always with the same liquid. The current neither varied in direction nor in intensity, at least in no sensible degree. If I employed water acidulated with sulphuric acid, instead of pure water, the current passed from the acidulated water to the blood in the lock, namely, in a contrary direction to the current obtained with blood and water. The contrary occurs with alkaline instead of acidulated water, namely, the current goes from the blood to the alkaline water, as it had gone from the blood to the water.

The results that we have just related prove to us that we must use great precautions when experiments on animals are made with a very sensible galvanometer; and they also explain to us a host of erroneous conclusions that have been drawn from experiments badly made.

We are now in a condition to point out another rule, which it is very necessary to follow, when we desire not to be deceived in the manner of making the experiments. This rule is traced out by the experiments themselves that we have related. We must always begin by leaving the two platinum plates of the galvanometer plunged together in a liquid. It should be of the same nature as that in which they will be plunged while the experiment is being made. And, if this experiment does not permit of the two liquids being identical, we must at least endeavour that they resemble each other as much as possible in composition, and in the degree of conductibility. When the two plates of the galvanometer are thus plunged into the liquid, we cannot commence an experiment unless the needle is at zero; and, before the commencement, we ought to remove them two or three times, and plunge them in again immediately: the needle ought not to move.

I will now suppose that a first experiment has been made, and that we wish to pass on to a second; we have still further precautions to take, which must not be neglected.

When any electric current has been transmitted in a liquid

Digitized by Google

by two plates of the same metal, it happens that, on again closing the circuit with these two plates, either left in their liquid, or removed into another, it happens, I say, that an electric current is produced, moving in the liquid in a contrary direction to the former; that is to say, that the platinum plate which had communicated with the positive pole becomes that into which the current enters on leaving the liquid. This current, which was discovered by Ritter, we call *secondary current.* The metal which produces this phenomenon better than all others is platinum.

It follows from this, that, on passing from one experiment to another, we must assure ourselves beforehand that the secondary current is finished, which is brought about by leaving the two plates immersed in the same liquid for a certain time.

It is useful in researches on electro-physiology to be able to compare together the intensities of two currents produced by two different electrometers. The more readily to explain the method which must be pursued for this purpose, I will suppose that we have two voltaic pairs, *a* and *b*; one of these pairs is formed of a plate of zinc, and one of platinum, while the other is composed of a plate of silver, and one of platinum. If we now wish to know the difference of intensity of the currents developed by these two different pairs, we oppose one to the other. For this we take three equal capsules filled with the same liquid. These capsules are inverted two by two by means of the two pairs, so that in the middle pair are plunged the plate of silver and that of zinc: in this way, in the two extreme capsules are the two plates of platinum. The experiment succeeds equally well if the position of the two pairs is inverted, so that in that at the middle are found the platinum and the zinc plate; and the silver in the extreme capsules. Things being thus arranged, the extremities of the platinum of the galvanometer are immersed in the liquid of the extreme capsules. Two currents circulate in the galvanometer; but as they move in opposite directions, the deviation obtained will be due to the difference merely of the currents; and we shall thus obtain the comparison of their intensities. The deviation obtained, when operating in this manner, is due to the current called *differential.*

It is advisable, in this chapter, to call to mind the laws of derived currents. Suppose I have a liquid mass traversed by a current: if the two plates of a galvanometer are plunged into this liquid a certain deviation is obtained, which is due to a current termed *derived.* I will here relate the laws of this phenomenon, as I have deduced them by experiment in

Digitized by Google

one of my memoirs. The direction of the derived current in the galvanometer is such, that the plate by which the current enters into the wire of the instrument is always that which is nearest to the positive pole of the current traversing the liquid. If this current is taken of a constant force, it is found that the derived current is greater in proportion as the two plates of the galvanometer, that are plunged into the liquid, are further apart. This derived current varies also with the extent of the galvanometer-plates plunged into the liquid. If the current is passed along a liquid canal, composed of two liquids, of different conducting powers, separated from each other by a membrane, a different derived current will be found; all other circumstances being equal, on plunging the plates either into one or the other of the liquids, the intensities of the two derived currents, obtained in the two liquids, will be exactly in inverse proportion to the conducting power of these two liquids. The stronger derived current will, consequently, be in the less conducteous liquid.

When the section of the mass traversed by the current is very extended, in comparison with the two surfaces of the poles of the pile, it is found that the derived currents, obtained by plunging the two plates of the galvanometer into different parts of this mass, vary in intensity in the different spots, so as to show that the current of the battery radiates by the two poles, spreading itself throughout the liquid. This radiation of the current is the greater in proportion as the liquid is a less efficient conductor. In this case, some traces of a derived current are even found behind the poles of the pile, always directed so as to enter into the galvanometer by the plate, which is nearer to the positive pole. These derived currents, that are found behind the poles, extend to a distance from these poles, which is always very trifling; and they are never found except in liquid masses that are very much extended in all directions, and are possessed of very feeble conducting power, and in which the current is transmitted by poles, whose surface is very small in comparison with the section of the liquid.

These laws of derived currents enable us to distinguish their existence from that of a current obtained by making the plates of the galvanometer communicate with the parts themselves of the electromotor. Indeed, if, on plunging the plates into the liquid, we find that the intensity of the current increases in proportion as the immersed plates are held at a greater distance, we may hence deduce with certainty, if nothing has changed in the experiment, that we are dealing with a derived current.—[A.]

Digitized by Google

LXXIX. *On the Relation that exists between the direction of the Electric Current, and the Muscular Contractions due to this Current.* By MM. C. MATTEUCCI and A. LONGET. First Memoir.—Read at the Academy of Sciences, at the sitting of Sept. 9, 1844. From a printed copy published by Fortin, Masson, and Co., Paris.

(TRANSLATION.)

UP to the present time, philosophers have studied the action of the electric current, *with different directions*, specially on the lumbar and sciatic nerves—namely, on the nervous cords which are called *mixed*, because they are composed of threads, some of which conduct impressions; and the others, the principal of muscular contraction.

This study, which was commenced by Lehot, and followed out by Bellingeri, Nobili, Marianini, and Matteucci, has demonstrated, that if, in a portion of the length of a nerve of this double nature (whether adhering or not to the cerebro-spinal axis), we pass *at once* a *direct current*, namely, one directed from the brain to the nervous extremities, contractions occur in the inferior muscles, as well on closing as on opening the circuit; and that the same phenomena are produced by an *inverse* current, namely, one directed from the extremities of the nerve toward the brain.

But the authors above mentioned soon perceived the appearance of another abiding period, in which the contractions occurred in only two cases: 1st, *at the commencement of the direct current;* 2nd, *at the interruption of the inverse current.*

This is the only general law hitherto admitted on the relation of the direction of electric currents with the muscular contractions that they excite, on passing into the nerves of living or recently killed animals.

The fundamental discovery of Charles Bell on the different functions of the filaments of the spinal marrow, and of the roots of the spinal nerves, induced us to investigate whether this law, which has been established by experiments prosecuted on mixed nerves alone, would be appreciable or not on the part of the nervous system, whose action is only centrifugal and exclusively motive; which implies that our researches would be first directed to the anterior spinal roots, and to the corresponding filaments of the spinal marrow.

In these researches, it is of importance always to submit the same anterior root to the same current;

To employ the latter so feeble at first that it scarcely gives rise to contractions;

Digitized by Google

Not to regard the first phenomena, which, on account of the too great excitability of the root are never very distinct; but to continue the use of the same current until a durable and constant effect appears;

To operate on the lumbar roots, because they present a greater length, and enable us more readily to avoid the distribution of currents into the neighbouring parts;

Thoroughly to dry up the blood, and to remove the moisture that surrounds the root on which we are operating;

To insulate the latter by means of a slip of varnished silk, or by a silk thread which ties it, and serves to raise without irritating it;

Above all, to insulate the pile with the greatest care,* which we can prove by touching the nerve separately with one or other rheophore; without this latter precaution, it would be impossible to know the direction of the current in the root; and the results would be equivocal.

We should further add, that, in these delicate experiments, if we suddenly augment the number of pairs, or if we make the current pass along a greater length of the root, we may see *for a moment* the re-appearance of a little confusion in the phenomena, namely, muscular contractions on opening and closing the circuit, whatever be the direction of the current: but the result which we are about to communicate will not fail to be produced with the greatest distinctness.

The anterior spinal root has been submitted to *direct* and *inverse* currents, under the four following conditions:—The anterior root and the corresponding posterior were untouched; both were divided; the posterior untouched and the anterior divided; the posterior divided, and the anterior untouched.

In all these cases, the contraction of the muscle or muscles animated by the anterior root, on which we are now occupied, are at first manifested confusedly at the commencement and at the end of the current, whatever be its direction; but after a certain time (a little longer, if the anterior root still adheres to the spinal cord) the effects become distinct and durable: *the contraction now takes place only at the commencement of the inverse current, and at the interruption of the direct current.*

This complete opposition to what is observed on mixed nerves (the sciatic for example, or *the spinal nerve taken immediately below the inter-vertebral ganglion*) induced us to repeat the experiments a great number of times on different

* We have employed a trough pile, charged with water, acidulated by nitric acid: this pile is convenient, because it permits of our varying the number of pairs as often as we may desire during each experiment.

Digitized by Google

animals: their results, which were established on the horse, the dog, the rabbit, and the frog, were invariable.

But, in order to produce them with certainty on the frog, it is indispensable (on account of the shortness of the roots, and the extreme facility with which the galvanic excitement is transmitted beyond the inter-vertebral ganglion, and consequently, to the mixed spinal nerve) to take certain precautions, which, although very simple, were not revealed to us until after long repeated trials. After having separated the spinal cord from the brain, and opened the spine on the side of the abdominal cavity, slips of varnished silk are passed beneath the anterior lumbar roots, which are left adhering to a sufficient length of the spinal cord; then, having cut all the lumbar nerves on the side opposite to that of the experiment, the extremity of one rheophore is applied to the anterior part of the spinal cord, and the extremity of the other to a point of the anterior root very near to this organ; in this case, the effects are soon manifested in as decided a manner as on the dog, namely, the contractions of the abdominal member are observed only in two cases,—at the commencement of the inverse current, and at the interruption of the direct current. But if, on applying the two rheophores to the anterior root itself, you come near to the inter-vertebral ganglion, and the excitation is transmitted to the mixed nerve situated immediately below this ganglion, you will see the phenomena inverted, and appearing as they occur in nerves which have not exclusively a centrifugal action, like the anterior roots.

A fact worthy of remark is, that, on continuing to make the current pass in the divided anterior roots (in the horse, dog, &c.) we observe that the muscular contractions, excited by the commencing inverse current, continue much longer than those due to the terminating direct current.

We now come to the influence of the current on the anterior and lateral white filaments of the spinal cord.

After having cut the cord transversely at the level of the tenth dorsal vertebra, and cut open the dura mater, which covers its caudal end, we divided and removed all the anterior and posterior roots to a level with the length of the anterior threads on which we proposed to operate; and having deprived them of the pia-mater, at the point where the extremities of the rheophores were to be applied, we discovered that the contractions occurred (after a few moments, or after the extinction of all *reflex action*) in the posterior train of the animal (a dog), only at the commencement of the inverse current, and at the interruption of the direct current, namely, as with the anterior roots.

Digitized by Google

With regard to the lateral threads, they re-act with *direct* and *inverse* currents in the manner of the anterior, occasioning, however, convulsive shocks, that are less durable and less energetic.

Our experiments on the anterior threads of the cord have been frequently repeated not only on dogs, but also on rabbits and frogs; and, finally, on a ring-adder. (*Coluber natrix.*)

If the phenomena that we have just made known are of a nature to rouse the attention of the philosopher, they may also receive from the physiologist some useful applications, and serve him to support with new arguments the distinction in the nervous system between the agents of sensibility and those of motion.

While admitting the different properties and functions in the two orders of spinal roots, a very large number of experimenters, especially in Germany, still entertain doubts of the *exclusively* motive mission of the white anterior* part of the spinal cord,—doubts which one of us endeavoured to dissipate in a work inserted in the *Archives Générales de Médicine.*†

Now, all uncertainty in this respect appears to us henceforth impossible, because, under the influence of *direct* and *inverse* currents, the white anterior threads of the cord constantly re-act after the manner of the anterior spinal roots, whose action is only centrifugal; and not after the manner of the sciatic, for example, whose action is centripetal and centrifugal—namely, sensitivo-motive.

Henceforth, physiology is found in possession of a sure means, borrowed from physics, of being able to distinguish the nerves which only conduct the principle of muscular contraction, from those which conduct at once this principle, and also peripheric impressions, and which we are accustomed to call *mixed nerves.*

But, at a variable distance from the cerebro-spinal axis, all the *mixed* nervous cords are not so to the same degree, that is to say, that a given cord, under a common neurilema, among a considerable number of motive filaments, presents but very few of the sensitive filaments from which the muscular system derives its peculiar sensibility (facial, hypoglossic, common ocular motor, spinal, or Willis's accessory nerve, &c.); whilst another given nervous cord is not only composed of the preceding filaments, but also of those which, being distributed to

* Inferior in the greater part of animals.

† Experimental researches on the properties and functions of the threads of the spinal marrow, and of the roots of the spinal nerves; with an historical and critical examination of the experiments made on these organs since those of Sir Charles Bell, 1841; by A. Longet.

Digitized by Google

the tegumentary system, are called upon to transmit impressions from the periphery to the encephalic centre; of this kind are almost all the nerves distributed to the thoracic and abdominal members.

It would, therefore, become interesting to know whether a similar difference in the constitution of the nerves might be revealed to the experimenters by varying the direction of the electric current. Now, we have said the most distinctly opposite effect is observed when they are directed comparatively on the anterior spinal root (purely *motive*), or on the spinal nerve (plainly mixed, or *sensitive-motor*), taken immediately below the inter-vertebral ganglion. It is a remarkable circumstance, that the same opposition in the phenomena no longer exists in so decided a manner in the nerves whose motive filaments predominate greatly over the filaments of mere muscular sensibility (facial, hypoglossic, common ocular motor, &c.); the results come out in some sort intermediate between those which we had obtained, on the one hand, with the anterior roots, and on the other with the spinal nerves irritated below the ganglions.* Hence it follows that the presence in a motor nerve of nervous fibres, of sensation or centripetal action, is sufficient to modify the phenomena, and that galvanism is a valuable agent to discover these fibres, even when the scalpel of the anatomist would be of no avail to demonstrate their existence.

On the other hand, let us bear in mind that the facial, hypoglossic, common ocular motor, spinal, &c., nerves, when taken at their origin, and before any sensitive anastomose, conduct themselves, when the direction of the current is changed, absolutely as do the anterior roots, and not like the mixed nerves.

Some German physiologists having considered the grey substance of the spinal marrow as being indispensable to the transmission of impressions, and of the principle of voluntary motions, we declare that, in the dog, we have constantly found it insensible and inadequate to provoke convulsive shocks under the influence of electricity and mechanical irritations; that its destruction, in as great a length as possible, by means of a stylet did not in the slightest degree modify the sensibility of the posterior medullary filaments, or the excitability of the anterior.

Let us further add, that *all reflex action* having disappeared in the caudal end of the divided cord (in the dog), the excite-

* Although more energetic at the commencement of the *inverse* current, and at the interruption of the *direct* current, the contractions slightly remained at the interruption of the former and the commencement of the latter.

Digitized by Google

ment of the posterior filaments never gave rise to the slightest muscular contraction, *whatever the direction of the electric current might be.* It is the same with the posterior roots, after they are separated from the spinal cord. On the contrary, if they still adhere to this organ, whether the current be inverse or direct, it is always when the *circuit is closed* that convulsive shocks are excited, which are evidently only due to an excitation reflected to the anterior roots, because the cutting of the latter instantly causes every contraction to cease.

Conclusion.—The influence of the electric current differs totally when it is exercised on nerves *exclusively motors*, the action of which is only centrifugal, or on *mixed* nerves, whose action is at once centrifugal and centripetal.

The former excite muscular contractions only at the commencement of the *inverse* current, and at the interruption of the *direct* current, whilst the latter make them appear only at the commencement of the direct current, and at the interruption of the inverse current.

The anterior filaments of the spinal cord conduct themselves with direct and inverse currents, after the manner of simple motor nerves.

This different and remarkable action of the electric current on nerves simply motor, or on those at once motor and sensitive, appears to us to furnish a sure means of distinguishing these nerves from each other; and, consequently, promises to serve to throw light upon a question, upon which physiologists are, even at the present day, divided, namely, to know whether there exist or not nerves that are *mixed* from their origin.

NOTE.—*In a forthcoming communication we shall have the honour of laying before the Academy the results to which we have been led by this means of experiment, when applied to the study of the great sympathetic nerve, and of the different encephalic enlargements, considered only in their immediate relations to muscular contractions.*

NOTE.

On the Hypothesis of Electric Currents in the Nerves.

Never having been able, in our former experiments, to establish, by aid of the galvanometer, the existence of electric currents in the brain, the spinal cord, or in the nerves of the dog, the rabbit, and the frog, we wished to make a new trial on an animal of large stature (*the horse*), hoping by this means to place ourselves in the most favourable condition for researches of this kind.

The galvanometer which we employed in these new experi

Digitized by Google

ments was constructed by Rumkorff, and was extremely sensible; the conducting wire, making two thousand five hundred convolutions, was furnished at each of its extremities with a *platinum plate*, fixed on an ivory handle, and so varnished as to leave only a square centimètre of its surface exposed. The needle made one oscillation in seventy seconds.

Before applying the two platinum plates to the nervous parts, they were immersed in spring-water for a very long time, and until the signs of the current, which are always observed at the first immersion, had completely disappeared.

These precautions having been taken, and the live horse having been thrown down upon a table, its sciatic nerve was insulated from the neighbouring muscles (by means of varnished silk) for a length of thirty or forty centimètres (upwards of one foot), was carefully wiped, and left in communication with the cerebro-spinal axis.

After being well assured that the needle constantly remained at zero, although either one or other of the platinum plates was removed from the water and alternately re-immersed, the plates were placed in contact, first with the surface of the sciatic, then, after the neurilema had been removed, with different points of this voluminous nerve.

The interval of deviation, namely, the distance comprised between the two plates, being at first 3 or 4 cent., the needle sometimes remained at zero, and at other times deviated several degrees, soon returning to zero. This interval having been suddenly extended to 15 cent., the deviation ought to have been notably increased, in the same direction, if electric currents existed in the nerves. There was nothing; or rather the needle did not deviate to a greater number of degrees than in the preceding case, and its deviation was still only momentary, or else was entirely wanting.

It is important to bear in mind that during the continuance of these experiments, in consequence of the pain which was voluntarily excited in the animal, its posterior train was the seat of energetic and repeated efforts, and that, consequently, the extremities of the galvanometer were put into communication with the sciatic nerve at the very moment when it was transmitting the exciting influence to the muscles of the thigh and leg.

If, by varying our trials, we have occasionally perceived a very sensible deviation of the needle, it is important to notice *that this deviation did not change in direction, although the contacts were inverted;* that, moreover, it so occurred every time that the nerve was touched *simultaneously* with the two plates of the galvanometer. At the moment when these plates were

Digitized by Google

successively plunged into water deviations were also obtained, which did not differ from those that are observed on inserting the extremities of the instrument in the nerve itself.

Bearing in mind the extreme sensibility of our galvanometer, the favourable condition of the experiment, and the precautions which we have taken, we think we are authorized in concluding that there does not exist any trace of electric currents in the nerves of living animals appreciable by the instruments we at present possess. In addition we may add, that our previous researches had already conducted us to the same conclusion.—[A.]

LXXX. *Memoir on the Measure of the Nervous Force developed by an Electric Current.* By M. Ch. Matteucci. (Extract by the Author.) From "Les Comptes Rendus," Sept. 16, 1844, Vol. XIX., No. 12, p. 563.

(TRANSLATION.)

In this memoir the author proposed to resolve the following problem:—A certain quantity of zinc being given, if it is employed in a pile, to determine what quantity of mechanical force is developed by a frog, whose lumbar nerves are traversed by the current produced from this given quantity of zinc.

The spinal cord of a recently prepared frog is secured by metal pincers: a certain weight carrying an index is attached to the two paws of the frog; a scale, divided into millimetres, is fixed vertically beside the index; finally, a platinum needle is introduced into the muscles of the pelvis of the frog, very near to the thighs. If the current is now made to traverse the pincers and the platinum needle, the frog will be seen to contract, and to raise the weight to a certain height in a certain time. By making this current pass at very approximate intervals of time, we have a succession of contractions or muscular efforts, which may be measured,—the weight raised, the time occupied, and the space traversed by this weight being given by the experiment. At the same time, a voltameter, included in the circuit, gives the quantity of electricity that has passed, and, consequently, the quantity of zinc dissolved. An idea of all the difficulties of the experiment may readily be conceived; and in the memoir, which I have the honour of presenting to the Academy, will be found all the precautions that I have employed. The principal point is, to operate with a current whose intensity is not greater than one that excites in the frog the maximum of contraction of which it is susceptible. Operating under these conditions, I have found that the muscular

Digitized by Google

effort was reduced one-half, if the current were diminished one-half; one-third, if the current were diminished one-third; and so on. The following are the numbers to which I arrived in the solution of the problem that I had proposed:—3 millegrammes of zinc, dissolved in a pile for four-and-twenty hours, produce a current which, in passing through the lumbar nerves of a recently killed frog, gives a quantity of work expressed by $5^{k}.^{m}.5419$; in the same time. If this quantity of work be now compared with that which would be obtained by burning the 3 milligrammes of zinc, or the equivalent of carbon under a steam-engine, we should have $0^{k}.^{m}.834$, which is a much lower number; in like manner, on making the current act in an electro-magnetic machine, we should have obtained only $0^{k}.^{m}.96$.

It follows from this, that the best condition for making an electric current produce the maximum of mechanical effect, is to cause it to act on the nerves of an animal. My memory deceiving me, I had thought the experiments of MM. Dulong and Despretz tended to prove that the animal gives to the calorimeter less heat than it developes by respiration; I then thought that the muscular force might be explained in an entirely hypothetical manner, by admitting the transformation of the electricity developed by a portion of the chemical actions of nutrition into nervous force. But as the very opposite effect follows from the experiments of these philosophers, the application of which I have spoken, in the memoir inserted in the *Annales de Chimie et de Physique*, third series, vol xi., cannot occur.

The importance of the inquiry that forms the subject of the present memoir, led me to require more delicate apparatus than I had hitherto employed in my experiments. For this, I had recourse to M. Breguet, whose kindness is inexhaustible, and whose talent is always equal to the difficult questions proposed to him. I have the honour of presenting to the Academy the apparatus that I have hitherto employed. The first improvement of importance introduced into my instrument is that of a very mobile ivory needle, which is thrust forward by the index when the latter is put in motion during the contraction: this needle remains at the spot, in order to mark out the space traversed by the index. Besides this, with three metal points fixed at the bottom of the weight that is to be raised,—points which plunge into two cups of mercury before the contraction occurs, and cease being immersed when the contraction takes place,—we are able to determine, by means of a chronoscope, the interval between two successive contractions. A temporary electro-magnet is introduced

Digitized by Google

into the circuit, and by a very simple arrangement is made to press against the button of the chronoscope. So that when the current commences, the chronoscope marks time; but the contraction takes place at that moment, the weight is raised, and the circuit is broken; the electro-magnet is detached, the contraction finishes, the weight falls again, the circuit is re-established, the current passes, the electro-magnet acts, and the chronoscope marks time. The second contraction takes place at the same time; the circuit is again broken; and so on. I will here relate one experiment that was made with M. Breguet, to test the working of our apparatus. Operating successively on different frogs, we found that for the first ten seconds, the interval between two contractions was 0″ 25; in the following ten seconds, this interval had become 0″ 33, and then 0″ 41, 0″ 58. This result is due solely to the reduction of power in the animal, and to the action of the current.

My only object for introducing these experiments here, is to make known to the Academy the very important amelioration which I have been enabled to introduce into my apparatus by the assistance of M. Breguet. I propose to continue these researches, which seem to possess some interest both to physics and to physiology.—[A.]

LXXXI. *Electricity developed in Manufacturing Processes.*

By. Mr. James Napier.

To the Editor of "The Electrical Magazine."

Mr. Editor,—In the last number of your *Magazine* (page 459), there is an account, by Mr. Armstrong, of electricity being developed in great quantities during the operations of manufacturing paper, or rather, during the processes of drying and glazing. After detailing the circumstances under which the phenomena are developed, he conjectures, as the cause of the high excitation of the paper, "the pressure it sustains in passing between the glazing rollers, and the separation which takes place on its leaving them." Phenomena similar to those described by Mr. Armstrong, are experienced by the dyer, and by all who are in the habit of drying certain goods at a high temperature, where there is neither pressure nor separation. In the second volume of the *Glasgow Practical Mechanic and Engineer's Magazine*, page 357, will be found the following notice:—"Pieces mordanted with acetate of alumina, and dried at a great heat, are highly charged with electricity. If

Digitized by Google

the hand be suddenly drawn along the piece, a complete shower of fire is observed with a sharp crackling noise,—at the same time a prickling sensation is felt."

Having often observed the phenomenon alluded to in this extract, I will describe (so far as my memory will allow me, for it is many years since I saw it) the circumstances under which it is developed. The drying-house or *stove*, where dyed or bleached goods are dried, is heated by a fire outside the building, but which is led by flues along the floor inside: the temperature of these places generally ranges from 120° to 150° Fahr. Poles are laid across a wooden frame-work, over which is hung the cloth or yarn to be dried. All goods dried under these circumstances are not charged with electricity; it depends a good deal upon the nature of the substance out of which they are dried, and also upon the state of the atmosphere of the drying-house: if this is at all moist, although the goods should feel perfectly dry, there is no development of electricity upon cotton, although some colours on silk will be charged even under these circumstances. I cannot recall to mind the different colours with which this phenomenon is particularly connected, or whether it depends upon the colour or the nature of the substance out of which they are dried; but I do not remember having seen goods electrically excited that were finished through what dyers term *softening*, which is a solution of soft soap, soda, and oil.

Sometimes the goods are so highly excited that sparks, visible in daylight, will be given off to an individual passing close to them; at other times they are only perceptible by drawing the hand suddenly along the surface, or grasping them firmly. Goods thus excited will retain this state as long as they remain warm, even after they are taken from the drying-house; we have observed it hours after they had been lying upon a stone floor, but in the heart of the bundle that had not lost its heat.

Silk is remarkable for this sort of excitement. A skein of silk, when dried in heat, has almost every thread apart; some of the threads appear to be exciting a considerable degree of force to keep themselves, or rather to be kept out from their neighbours: the loose threads are stretched out in a horizontal line.

I am sorry, Mr. Editor, that I cannot be more definite in the details; my reason for troubling you is in the hope that it may attract the notice of some who may have opportunities of observing the same results, and carefully noting down the different circumstances attending them, as it may throw

Digitized by Google

some light upon the electricity of evaporation, so intimately connected with meteorology.

I am, Mr. Editor, yours,

JAMES NAPIER.

Postscript, Nov. 16.—Since writing the above, a dyer has given me the following information :—

"It is necessary that the heat be at or above 120° Fahr., and that the goods be perfectly free of damp. Bleached cotton is very full of fire; so also is black, dyed in the usual way—that is, by sumach, copper, and logwood. Dark logwood browns are the most full of fire: they are dyed by being first passed through sumach, then into a solution of chloride of tin, and afterwards through a decoction of logwood, they are generally washed in cold water previous to drying. Light browns have a little electricity, but not so much as dark brown or black. It is occasionally developed by browns dyed in catechu, and has also been seen in oranges dyed by bi-chromate of potash, and finished through hot lime-water. When there is much *softening* used, there is no fire. I have never observed any on indigo blues, or on greens, or ambers."

J. N.

LXXXII. *On the Electricity produced in Manufacturing the Machine-Paper.* By Dr. HANKEL. From "Poggendorff's Annalen." Vol. XXXI., p. 477. 1842.

(TRANSLATION.)

THAT paper, when warmed, and afterwards rubbed on a table with a brush or with Indian rubber, presents very marked electric indications, is an experiment which is undoubtedly very well known. However, I think that the following short notice of the appearance of very powerful negative electricity, during the manufacture of machine-paper, will be interesting. This phenomenon was mentioned to me by M. Keferstein, a paper-maker at Krollwitz, near Halle; and I have myself had the opportunity of observing the same. When the paper has left the rocking-table, and the water has partly run through the wire-frame that passes, on an endless band, over a couple of rollers, and is then pressed out by a roller placed near the wire frame; the paper thus made still remains damp, although it possesses some degree of solidity; it thence passes over to the rollers, which are heated by steam, and is accompanied among the first three by a hair-cloth, but goes over the fourth

Digitized by Google

without the aid of a hair-cloth; after it has gone between the last pressing rollers, the very wide paper-sheet is cut into three narrow strips, of the width of an ordinary sheet of paper, by sharp circular cutters placed in a roller, and it is then rolled upon a cylinder. So long as the paper is accompanied by the hair-cloth, no signs of electricity are manifested; they appear, when it leaves the last steam-roller or rather the last pressing-roller.

It appears by experiment that the heat of the last steam-roller exercises great influence, inasmuch as the electrical phenomena are much stronger the more the heat of the last steam-roller is increased; they are frequently so strong that very loud sparks dart from the paper to the last smoothing-roller (a small guiding roller of copper), and to the roller on which the cutters are fixed. If the finger is brought near to the paper, a rapid succession of small sparks are perceived to pass from it to the paper. A Leyden jar can easily be charged. The electricity remains in the paper for a considerable time.

When only a few coils of paper are on the cylinder, the electricity is feeble; but it increases considerably with the number of folds; if the paper is cut away from the cylinder, and the long strips are thrown asunder, many strong and very brilliant sparks fly between them. This electricity is evidently produced merely by the heating of the paper, and its being pressed by means of the rollers. No friction can take place, because the velocity of the circumference of all the rollers is exactly the same. The evaporation of water is certainly no cause of the electricity appearing at the end of the machine; since, just in those parts where the evaporation is the strongest, no signs of electricity are manifested; and the damp paper being a conductor conveys all that is so produced to the metal rollers.

Note.—Compare *Gib. Ann.* vol. lxxv. p. 197.—I take the liberty of observing, that the appearance of electricity in the fabrication of paper is no new phenomenon: probably there are few proprietors of such manufactories who have not noticed it, as it is even a hindrance in folding the paper. In the mean while, this phenomenon has not been mentioned in the *Annalen;* nor, so far as I can discover, has it been noticed in works on natural philosophy; on which account the circumstance may be unknown to many readers of this Journal.

A similar production of electricity has for many years been noticed in Mr. Macintosh's manufactory at Glasgow, on tearing asunder the well-known water-proof cloth, which is

Digitized by Google

stuck together by means of a solution of Indian-rubber in coal-tar,*—(*Edin. Phil. Jour.* vol. x. p. 185.) Lately, also, they have been seen by Mr. Marsh at Woolwich, on grinding newly roasted coffee in an iron coffee-mill; they passed between the mill and a tin can placed $\frac{1}{10}$th inch distant.—(*Ann. of Elect.* vol. viii. p., 124.) Lastly a very strong attraction has been noticed in a cotton-mill, in a broad endless band, that passes horizontally over two cylinders of almost three feet in diameter, which revolves seventy-two times in a minute.—Cotton-wool was attracted from a distance of two or three feet; and, four feet beneath the band, the hair of the workmen stood on end.—(*Ann. of Elect.* vol. v. p. 397.)—*Editor of the Annalen.*

Note.—It is but due to Mr. Armstrong to state, that he had not seen, nor was he aware of the existence of Dr. Hankel's pages, when he was writing the communication given in *The Electrical Magazine*, No. vi. p. 459; so that his opinions there expressed are to be esteemed as genuine. We are indebted to him, and also in our present number, to Mr. Napier, for supplying the scientific world with the facts presented in manufacturing processes; we have little doubt that many similar phenomena are in existence if we were but aware of their lurking-corners. The following is an extract from a note to us by Mr. Pollock, bearing date July 5, 1844; in reference to Mr. Elliot's Mill, near Chesham, Bucks:—

"From the wooden roller, round which the paper is collected at the termination of the process, sparks to the extent of 10 or 12 inches are produced.

"From the information given me by Mr. Elliot, it seems that the pressure upon the paper while passing the two rollers is the cause of the electricity; for, when the width of the paper is such as to cover the whole breadth of the cylinders, little electricity is produced; but when half that width, then the effects occur as above stated. This Mr. Elliot attributes to the weakening of the pressure by extending the surface. He does not think that the composition of the paper makes any difference, as several kinds produce the same effect."—*Ed. Elec. Mag.*

LXXXIII. *The Lightning Conductor of the Royal Exchange*, by Charles V. Walker. From "The Times." Oct. 30, 1844.

Sir,—Being assured that the citizens of London will feel a

* We may mention that the two cloths are passed between two steam-rollers highly heated; and that the adhesive solution is between the cloths as they enter the rollers.—*Ed. Elec. Mag.*

Digitized by Google

satisfaction in knowing that their new Royal Exchange is protected against one form of the element by which the former edifice was razed to the ground, I venture to ask a place in your journal for a description of the lightning conductor.

Experience, very dearly purchased, has taught us to regard these appendages as of prime importance to every exposed or elevated structure, and has convinced us that the immunity from danger which has been enjoyed by many an unprotected building has been merely accidental; for when "time and chance," so to speak, have wafted the teeming thunder-cloud within range of the edifice that had so long remained unscathed, the delusion has vanished, and the shattered towers (as those, for instance, of Spitalfields, Streatham, Brixton, and St. Martin's churches), have borne testimony to the sad reality.

The lightning conductor of the Royal Exchange has been erected essentially as a conductor of lightning; it is not placed there under the idea that it will avert a lightning flash by draining the cloud of its electrical contents; nor will it invite a lightning flash by any attractive power inherent in itself; but it is there, ready to receive any flash that may strike it, and to conduct it in safety to the earth. It is presumed that the time may come when a cloud shall pass over the tower at the precise moment when its electrical contents are in such a state of "tottering equilibrium," that its inductive action on the conducteous bodies there present will be sufficient to overthrow this equilibrium and cause the discharge. The apex of the conductor is, therefore, so presented to the cloud, as to be more accessible to the flash than any other conducteous body; and with the broad fact before us, that the flash is journeying onward to the earth, and will arrive there by the course opposing least resistance, every precaution is taken not merely that the conductor shall be the path presenting least resistance, but that it shall be a path large enough to convey away any lightning flash whatever. In other words, we presume that the conductor may one day be struck with lightning; and knowing that the object of the lightning is to reach the earth with the least possible opposition, we provide for it a path, not only efficient in itself, but likewise more efficient than any other vicinal path or paths.

The conductor is a copper rod three-quarters of an inch in diameter—a size more than sufficient to conduct safely the largest lightning flash; for experience has not furnished us with any cases wherein a mass of copper of only half an inch in diameter has been melted by lightning; while many instances are extant of heavy discharges being safely conducted by smaller rods. It commences with a rod of copper, tipped and

Digitized by Google

pointed with platinum, erected on the back of the grasshopper vane, immediately over the spindle; and terminates in a furcated form within a pit sunk near the base of the tower. As a lightning conductor is a most dangerous appendage unless its base is very effectually connected with the subsoil, the greatest attention has been paid to this point. The pit was sunk through the concrete until the native gravel was fairly entered; the furcated terminating portion was then attached, so as to reach to the bottom of the pit; a ton or two of the graphite, obtained from gas retorts, was broken small, and thrown into the pit, so as completely to bury the furcations. I may mention that this material, besides being indestructible, is an excellent conductor of electricity; and that it is employed in order to present as large a conducting surface to the soil as possible, and so to facilitate the escape of the charge, and thus make the conductor in every respect the path opposing least resistance. The pit was then filled up.

As the supply-pipe by which the Exchange is furnished with water passes at no great distance from the spot where the conductor enters the court-yard, the pipe has been connected with the conductor by means of a copper rod; and thus the whole mass of the water-pipes throughout London constitute an infinitely extensive discharging train. So perfect is this discharging system, that I could have contented myself without the pit of graphite, had I not looked through the vista of years to the time when these water-pipes might be removed or altered. The workmen would detach the connexions, and, if unaware of its nature, which is more than probable, they might replace the pipes without attending to the apparently useless rod of copper.

The course of the conductor is not obvious to the passer-by, for I have not cared unnecessarily to create an eyesore on the architecture of the tower. I have, therefore, carried it within the tower from the vane to the belfry, and have then led it out, so as to pass over the parapet at a level with the roof of the building, and to descend into the inner court at the right hand on entering. Throughout its course the conductor is a perfect fixture, being secured to the wall by copper staples a few inches in length.

There is one question which always arises in respect to lightning conductors, and in answering this another essential feature will be recognized. Is it possible for any portion of the flash to leave the conductor? Yes, in extreme cases it is just possible. When? Whenever a path is at hand which with the conductor (during the whole or a portion of the rest of the course), presents less resistance to the particular

Digitized by Google

flash in question than is presented by the conductor alone; in other words, the clock-room and the belfry contain large masses of metal which might, in an extreme case, relieve the conductor in this part of its course of a part of the charge. This remote contingency must, therefore, be provided against. Now, lightning is mainly a destructive agent during its transit from metal to metal, through stone and wood, and such like bad conductors; while travelling in capacious masses of metal it is perfectly harmless; therefore, in order to prevent its attaining to these masses of metal through the intervention of bad conductors, the clock and the bells are respectively connected with the lightning conductor by a series of copper rods, so that, should the case ever occur in which a portion of the charge should claim the supplementary path presented by these necessary appendages to the tower, it will pass innocently to them in the first instance, and from them afterwards, without any flash or explosion being made manifest. In like manner, where the conductor passes over the parapet, near the gutters and water-spouts, a copper rod is led away to the nearest gutter, and secured to the metal of which it is constructed. By these means the whole of the metal-work about the building is included in the general system; and no supplementary or side path is open to the flash that is not in perfect metallic connection with the rod itself.

I have embodied in this description the principles by which we are guided in erecting a lightning conductor, because I wish it to be of some practical use to your readers. I cannot consistently trespass on your columns to enter into the minute details; it is enough to have put forth the broad and very general features that are applicable to all cases. It is to be hoped that the example set by the architect of the Royal Exchange, and by those under whose directions several other public edifices have been erected, will be followed out as a general rule, and not stand as an exception; and that our temples and our national edifices may not stand, as they constantly do, boldly thrust up into the region of storms, as if daring the fury of the tempest, and inviting down its vengeance.

I remain, Sir, your very obedient servant,

CHARLES V. WALKER.

Westbourne-Green, Oct. 28.

Digitized by Google

LXXXIV. *Has Captain Warner a secret?* From the "Athenæum," No. 877, Aug. 17, 1844.

In answer to this important question, I send you the following extracts from *Miles's National* (American) *Register*, for July, 1842. Yours, &c.

Colt's Submarine Battery.

Mr. Colt made an experiment on Saturday with his newly invented Submarine Battery, which was considered as highly satisfactory. The explosion took place opposite Castle Garden, and was attended by a dull, heavy, rushing sound; and a huge column of water was thrown suddenly and violently to the height of twenty or thirty feet in the air. The can containing the combustibles was sunk under the hulk, and a wire connected from it to the deck of the North Carolina, some two or three hundred yards distant. At the moment fixed, Mr. Colt, on the deck of the North Carolina, applied the acid to his plates (voltaic plates), and quicker than thought the deck was thrown into the air, and scattered into fragments. A more complete experiment never was performed. Tens of thousands of people witnessed it from the Battery. * * *

Another account says:—Mr. Colt, having his magnetic battery ready on the quarter-deck of this ship, the wires having been prepared under water, and connected with the explosive machine under the ill-fated vessel, said to the gentlemen, "I am ready; look out!" when, with the quickness of the electric flash, the vessel was blown up into ten thousand fragments. The suddenness with which the vessel, which I suppose to have been of some hundred tons burden, disappeared, was more like an optical delusion than reality; for in the twinkling of an eye the form and fashion of the boat was changed into a column of water and fragments. * * And, now the scene was closed, all hands awarding to Mr. Colt the praise of having struck upon a device that will be a more certain protector of our ports and harbours against invading fleets, than would scores of batteries and men-of-war; for against these visible agents of defence, power can be employed and applied, but against this *immersed, hidden, and invisible agent*, with power enough, in a moment, to blow to atoms the proudest navy that floats, no power can be applied, and no vigilance guard against its devastating effects.

In the same work, and in the next month, August 27th, we find the following:—"*Colt's Submarine Battery.*—Mr. Colt succeeded in the exhibition of his apparatus on the 23rd,

Digitized by Google

at Washington, as was witnessed by the President of the United States, heads of departments, members of Congress, public officers, and thousands of spectators." The consequent proceedings in the House of Representatives are reported in the following letter:—[Tuesday, August 23, 1842,] "Resolved, That the secretary of the navy be, and he is hereby, instructed to render Mr. Samuel Colt facilities to test his Submarine Battery to an extent which will settle the question, whether these can with ease and safety be successfully employed as a power sufficient to destroy the largest class of ships of war when in motion, passing in or out of harbour, without *the necessity* of approaching within *reach of shot from guns of the largest calibre;* and whether continued operations of the destruction of one or more vessels can be effected without renewing the means, under exposure of an advancing squadron; and whether the same can be used for the defence of a harbour, without endangering the passage in or out of other than hostile vessels. And be it further resolved, that, should Mr. Colt's Submarine Battery stand the above tests, he is hereby authorized to proceed, under the direction of the President and the Secretaries of the Navy and of War, to fortify whatever harbour may be agreed upon for that purpose, provided he will undertake the same at the mean cost of the United States' steam-ships, Missouri and Mississipi. The necessary expenses to be paid out of any money in the treasury, not otherwise appropriated." * * On the motion of Mr. Mallory, the resolution was referred to the Committee on Naval Affairs; and on Sept. 3rd, 1842, "Mr. Archer, from the Committee of Naval Affairs, reported the joint resolution (in the Senate) of the House," to authorize experiments on Colt's Submarine Battery.

On the 14th of October another experiment, similar to that above referred to, took place at New York, in presence of the Secretary of War, Adjutant-General Jones, a number of officers of the army and navy, and forty thousand spectators. This is the last notice of the subject which I find in my file of *Miles's Register,* which, however, only comes down to Sept. 25, 1843. The report may or may not have been since made.

Digitized by Google

LXXXV. *Note upon the Direction of the Needle in China, and upon Auroræ Boreales observed in the same country.* By M. Ed. Biot. From "Les Comptes Rendus." Oct. 21, 1844. Vol. 19. No. 17, p. 822.

(TRANSLATION.)

Having been engaged in extracting from the Chinese annals the indications of auroræ boreales that might be found in them, from ancient times up to the present day, I felt that, in order to derive any practical advantage from these observations, I ought first to endeavour to determine, as far as possible, what must have been the direction of the magnetic needle at the same periods, in the places where these phenomena had been observed. I could not expect to find in these texts any documents relative to the dip, which, even in Europe, was not measured with any accuracy until after 1750; but the constancy or variability of its declination was a fact, the discussion of which would be more accessible. I therefore commenced by examining this point.

In the writings of the missionaries Gaubil, Amyot, and others, there are accurate observations on the declination, made at different places in China, which go back as far as the commencement of the 18th century, and even to the end of the 17th. On comparing them with the analogous observations more recently made, both by land and sea, by sailors or by travellers in these same latitudes, we see that, from the end of the 17th century until the present time, the declination has remained nothing or very little in China, or even more generally between the parallels of 59° N. and 7° S., and between the meridians of 102° and 133° E. of Paris. This is the conclusion deduced by M. Duperrey, from a special work on the subject, which he has been good enough to transmit to me.

To descend backward to earlier dates, I first consulted the same Chinese works that M. Klaproth had explored before me, when drawing out his letter on the invention of the compass, addressed to M. de Humboldt, and printed in 1834. I verified all the passages quoted by M. Klaproth; and I have further been able, through the obliging assistance of M. Julien, to discover in the original works certain important passages which M. Klaproth had not found in the incomplete parts contained in the dictionaries and encyclopædic collections, drawn up at various times by the Chinese *savans*. I have thus been enabled to translate these passages entire; and, in fine, the following are the principal facts that I shall put forth in evidence as the results of my researches:

Digitized by Google

An ancient tradition, mentioned for the first time in the *Kou-kin-tchu* of Thsouï-pao, an author of the 4th century of our era, attributes to the ancient sovereign Hoang-ti, placed by computation in the 27th century before Jesus Christ, the invention and use of a car furnished with an instrument that would indicate the south. Other more modern authors than Thsouï-pao, among them the Chinese *savans*, who, in the 12th century, drew up the great historical compilation entitled *Thoung-kien-khang-mou*, attribute this same invention to Tcheou-kong, the great astronomical prince of the 11th century before our era. They speak of a car indicating the south, which had been given by Tcheou-kong to the ambassadors of a foreign prince; but this account is merely founded on a single tradition, although its authors have supported it by the name of the celebrated Sse-ma-thsien, who wrote about 100 years before our era. The most ancient historical quotation relating to this car that indicates the south, appears to be that which is found in the work of Han-feï-tseu, a philosopher of the sect of Tao, who lived in the middle of the 4th century before our era. This author, quoted in the encyclopædic collection, "Iu-hai,"* says: "The ancient sovereigns established *indicators of the south* (*Sse-nan*), to distinguish the side of the morning (the east) and the side of the evening (the west)." The commentator of Han-feï-tseu, adds: "*Sse-nan* is the car to indicate the south, *Tchi-nan-tche.*" I may observe that even to the present day this name of *Sse-nan* or *Tchi-nan* is employed to designate the compass, without adding to it the character *Tchin*, needle. Four centuries after Han-feï-tseu, about the year 121 of our era, under the Emperor Nganti, of the dynasty of Han, there appeared a very valuable dictionary called "Chouewen," in which we find the character *Tseu* (magnet) thus defined: "*Name of a stone with which the needle is directed.*" The close accordance of these two passages, written at periods not far distant from each other, denotes the knowledge of the compass or magnetic needle in China at least from the first centuries before our era; and the custom of observing its south instead of its north pole is preserved among Chinese sailors to the present time. In the middle of the 3rd century of our era (3rd year, *Thsing-loung*, the year 235) the annals of Weï mention cars indicating the south, constructed after the model of the preceding dynasty—that of Han. These cars are quoted in the official history of the dynasty of Tsin, who reigned between the years 265

* *Ju-haï*, in the section of cars; article *Sse-nan-tche*, of Tcheou. This work exists in the royal library.

Digitized by Google

and 419 of our era,—in that of the Tartar prince Chi-hou, who occupied the north of China from the year 335 to 349,—finally, in the official history of the first dynasty of Soung, who reigned in the south from 420 to 477. This latter history, after mentioning the cars, adds: "Under the Tsin dynasty" (265 to 419 of our era), "there were also ships indicating the south."

On the other hand it is agreed that the Chinese, from very remote antiquity, have known how to trace meridian lines, and to give direction to their edifices by observation derived from the rising and setting sun, and by observation of the polar star of the period. These two methods are recorded in the article *Tsiang-jin* of the 6th section of *Tcheou-li*—a section anterior to our era by several centuries; and also in *Tcheou-peï*, a work of which the last edition cannot be later than the 2nd century of our era. Therefore, since the Chinese at that time were cognizant of a method of tracing meridians by the observation of the polar star, and of the sun at its rising and setting; and as, at the same time, they employed instruments indicating the south (which could only have been needles or magnetic bars), it follows that the declination must have been nothing, or very feeble, about the epochs mentioned (namely, in the first centuries of the Christian era), as it is at the present time; otherwise the difference of the lines given by either method could not have escaped the Chinese, who preserved these *cars indicating the south* in the imperial palace, which was always directed regularly in all its parts.

The cars indicating the south are again described in Chinese annals for the years of the period 806-20 of Jesus Christ, under Hien-thsoung, of the Thang dynasty,—for the years 1027-53, under the Emperor Jin-thsoung, of the great Soung dynasty; but in a work entitled "*Mung-khi-pi-than*," composed about the end of the 11th century,* we find an extremely curious passage on the magnetic needle. I will report this passage entire, of which M. Klaproth has given only the first line from the quotation of an encyclopædic dictionary; and it will serve to confirm the analagous passage, translated by M. Klaproth, from the "*Pen-thsao-yen-i*" of *Keou-thsoung-chi*, a work of an almost identical period (1111 to 1117 of the Christian era). I should recall to mind, that Gaubil, page 100 of his "*Astronomie Chinoise*," had already pointed out this second passage, and the notions it contains on the magnetic needle; but he had not given the translation.

* This work exists in the royal library, in the collection entitled "*Tsin-taï-pi-chou*. I owe a knowledge of it to the kindness of M. Stanislas Julien.

Digitized by Google

The following is the entire passage from the *Mung-khi-pi-than*, book 24th, *Thsa-chi*:—"Those who practise magic rub a needle with the magnet-stone, it can then point to the south: however, it constantly declines a little to the east: it does not exactly indicate the south. When this needle floats on water, it is greatly agitated; if the nails of the fingers touch the upper part of the edge of the basin in which it floats, they can cause it to be agitated very violently; only it continues to slide, and easily falls. It is better to suspend it, in order to manifest its virtue in the best possible manner. The following is the mode:—We take a single thread from the middle of a new skein of cotton; with a little wax, as large as a grain of mustard seed, we attach it exactly to the middle of the needle, and suspend it in a place where there is no wind; the needle then constantly points out the south. Among these needles there are some which, when rubbed, point out the north. Our conjurors have some which point out the south, and others which point out the north. No one has been able to give the origin of this property, which the magnet has of pointing out the south, like the property possessed by the cypress of pointing out the west.

This singular tendency toward the west, attributed to the cypress, is reproduced in the Medical Herbal, *Pen-thsao-kang-mou*, article *Cypress* of the Japanese Encyclopædia, book 82, and is in a like manner compared with the property possessed by the magnet of indicating the north, but without any further explanation. Whatever the cause may be of this, limiting myself to the subject of the present note, it follows, from the preceding description, that the observation of the direction of the needle floating on water must have been very uncertain, on account of the agitation of the water, and the formation of a meniscus near the edges of the basin, if it were not very large; furthermore, the needle slid by the magnetic force in the direction of the dip; and, as the Chinese text says, its polarity was more surely observed by suspending it with a cotton thread; the needle then pointed exactly to the south; and thus about this period the declination of the magnetic needle was either nothing or scarcely sensible in China. This conclusion is also derived from the passage from the *Pen-thsao-yen-i*, translated by M. Klaproth, *Lettre sur l'Invention de la Boussole*, p. 69.

In the 14th century, in the period *Yen-yeou* (1314-20), a car, indicating the south, was employed for giving direction to the monastery of *Yao-mou-ngan*, and to determine its position. This fact is related in the Encyclopædia, *San-thsao-*

Digitized by Google

thou-hoeï, book v. fol. 10;* and, without dwelling too much on the dimensions assigned by the Chinese text to the figure indicating the south, which was carried in this car, it is evident here also, that they would not unreservedly have made use of this figure indicating the south to give direction to the walls, if this direction sensibly deviated from the meridian. The regular employment of the compass in China to give direction to the walls of houses is established by the *Miroir de la Langue Mantchoue*, quoted by Klaproth, p. 109 of his *Lettre sur l'Invention de la Boussole*, and by a letter of P. Amyot, vol. 4, of the *Memoirs des Missionaires*, p. 2; where it is said that the Chinese place sun-dials with the compass, admitting two degrees of declination to the west. According to Gaubil, this is precisely the deviation toward the west of the E. and the W. walls of Pekin, built under the second Emperor of the Ming dynasty, in the period 1399-1403.†

Gaubil says, in his *Histoire Abrégée de l'Astronomie Chinoise*, p. 100, that Tching, prince of the imperial family of Ming, who, before the arrival of the Jesuits, wrote a considerable work on astronomy, gave instructions for ascertaining the declination of the magnet by applying the needle to a meridian line. I have not been able to find this work, which Gaubil possessed, as he says in a note; but M. Julien has communicated to me a passage from a work entitled: *Description of the Astrological Compass* (*Lo-king-kiaï*), and published in 1618, in which it is said that through *Jin* (W. $\frac{5}{6}$ N.),‡ and *Tseu* (N.), through *Ping* (E. $\frac{5}{6}$ S.), and *Ou* (S.), the mean line of the sky and earth, the precise direction of the north and south passes. "The sky," adds the text, "is represented by the twenty-four stellar divisions. It constantly turns to the right (looking at the south). In one day, it makes one revolution; and each revolution, passing on one degree, inclines toward the point *Jin* (W. $\frac{5}{6}$ N.). The sky, therefore, inclines toward the N. W.; but, in the system of the needle, it ought to incline or deviate toward the point *Ping* (E. $\frac{5}{6}$ S.);" which the text explains by the action of the fire of the south on the metal. Through the astrological ideas, which I shall not undertake to explain, we here also see that the declination of the needle is indicated as being only one degree, at the commencement of the 17th century,—a period to which the first

* *Vide* Klaproth's translation; *Lettre sur l'Invention de la Boussole*, p. 92.

† Gaubil, *Description de la Ville de Peking*, p. 8.

‡ The Chinese compass is here divided into twenty-four parts, according to its more common division. Each quadrant, therefore, contains six parts. (*Vide* M. Klaproth's Letter on the Compass.)

Digitized by Google

European observations, made on the littoral meridian of China, reach. These observations give 1° 30′ toward the west, from the table communicated to me by M. Duperrey.

Summing up all these extracts, we see that we may adopt, as a definite conclusion, the approximative constancy and the smallness of the declination of the magnetic needle in China, from ancient times to the present day.

With regard to the dip, we have observations made by the Russians on the meridian of Peking or the neighbouring meridians; and these observations are almost all for the years 1830 and 1831. At Macao alone, Cook's observations, in 1780, compared with the recent observations of 1837 and 1841, indicate only three degrees of variation during 16 years; whilst in Europe, according to M. Arago's observations, the dip has undergone very considerable changes. Now, on examining the summary of magnetic phenomena on the different positions of the terrestrial globe, as was done by M. Duperrey, this philosopher was able to establish that the mean meridian of China is also one of those on which the dip ought to experience the least variation for many centuries; so that, on taking this element into modern observations, on places situated under the meridians in question, there is a very great probability that it may be applied without much error to the most ancient times.

I have endeavoured to confirm the two results that I have just laid down, by examining all the descriptions of phenomena analogous to auroræ boreales that may be contained in Chinese works. Indeed, as the magnetic meridian has almost coincided with the terrestrial meridian in China from ancient times, the centre of the great arcs of auroræ boreales observed in this country, and the centre of the convergence of their luminous jets must have been situated on the terrestrial meridian of each place of observation. In the hope of verifying these two facts, I explored the whole astronomical portion of the great collection of Ma-touan-lin, entitled *Wen-hian-thoung-khao*, and continued by a supplement to the 17th century of our era. I have thus collected the mention of more than forty appearances, the identification of which with auroræ boreales does not seem to me to admit of doubt; and I have translated the text of these observations, comparing it with the original text of the annals from which Ma-touan-lin has drawn extracts. But this text is generally not very accurate, and the descriptions are very vague, although exempt from the marvellous which disfigures the descriptions of the same phenomena in the chronicles of our European middle ages. I do not, therefore, presume that it will be necessary to publish

Digitized by Google

all these Chinese observations; I will confine myself to presenting the conclusions that may be deduced from their examination.

First, in the great majority of observations, the phenomenon is described as a red vapour, resembling a great fire, with the brilliancy of the sun, or with the light which colours the horizon when the moon is about to appear. This vapour presents itself on the north side, and extends almost equally to the N. W. and N. E.

Several times the texts say that this red vapour covers the *Peteou*, corresponding to the seven principal stars of the Great Bear; or, at other times, it occupies the position of the Blue Palace, which nearly corresponds to the place in our planispheres, surrounded by the tail of the Dragon. The hour of the observation is mentioned but once.

From these two classes of observations, it seems to me to follow that the middle of the phenomenon is directly north.

Almost all the appearances mentioned in the Chinese annals were observed between the 32d and 35th degrees N. latitude. In these comparatively low latitudes, they do not generally present the different characteristic circumstances which accompany beautiful auroræ in high latitudes. Sometimes the text notices that luminous jets (literally *serpentine arrows*) have appeared in the sky, and glided away toward the south or the west. They also mention the appearance of large white arcs, but without saying whether these arcs were complete or not; and without distinctly indicating the points of the horizon to which they abut. They cite some auroræ in the south, the south-west, and in the west.

Finally, from among the forty appearances that I have collected, I will select two, which seem to merit being quoted entire, because the text determines the point of convergence of the luminous jets,—and the situation on the terrestrial meridian of the places of observation: which agrees with the results deduced from my discussion on the magnetic needle. The first of these appearances is for the year 616 of our era; the second is for the year 905.

"616, 20th Oct.—Under Yang-ti, period *Ta-nie*, 12th year, 9th moon, *Wou-ou* day, serpentine arrows came out from the group of *Pe-teou* (the seven principal stars of the Great Bear); they were agitated together like a collection of serpents, and passed away toward *Teou* of the south (group formed by ξ, λ, σ, τ, ϕ, Saggitarius)."

"905, 12th April.—Period *Thien-youen*, 2d year, 3d moon, *Y-tcheou* day, in the night was seen a large star, which came out from the middle of the sky; it was as large as a five-

Digitized by Google

bushel measure. It passed towards the N. W., to a distance of about 100 feet from the earth, and stopped. Above it was a cluster of stars; it burned like a yellowish-red flame, 50 degrees in length, and moved in a serpentine direction. All these little stars moved and fell in the S. E., like a shower; in an instant they disappeared. There was then seen a whitish-blue vapour, resembling a bundle of bamboos, the upper point of the union of which was in the middle of the sky, and the brilliancy of which fatigued the eyes."

In finishing this note, I should recall to mind that the first positive mention of the aurora borealis in the Chinese records goes back to the year 208 before our era.—[A.]

LXXXVI.—*Facts and Observations relative to the Production of Light from Voltaic Currents; with Suggestions for the Application of Subterraneous Batteries to the Purpose of Artificial Illumination.* By W. H. Weekes, Esq.

1. If we might venture to decide upon three principal elements more eminently essential to the advancement of superior civilization than those ordinary constituents of conventional systems, which blend and harmonize generally to promote the moral and intellectual development of a people, we should perhaps not err in yielding our preference to the following considerations:—*First*, the secure and expeditious means of locomotive transit, both by land and ocean; *secondly*, a cheap medium of correspondence and active post-office regulations; and *lastly*, an universal system of public illumination, characterized by economy and simplicity. While the hand of science has in a great degree accomplished the former of these objects, it must, I think, be now freely admitted that legislation has done its utmost, in this country at least, towards completing the next great desideratum; and it remains only to inquire whether our system of public lighting admits of similar improvements in regard to its economy and effects.

2. It must, indeed, be a blind devotion to the purposes of innovation, which would fail to recognize the triumphs of science so ably displayed in our admirable system of gas lighting; yet we ought not to close our eyes to the fact, that these advantages are purchased at an immense expenditure, both of money and material, while it is evident—although it is not my present purpose to discuss this point—that the latter must, in the lapse of ages, cease to be supplied by the (not boundless)

Digitized by Google

stores of nature. The question, then, is,—Can an equally efficient, if not superior, system of lighting be substituted, *independent of the rapid consumption of material, and certainly consistent with a diminution of expenditure?* I venture to answer, yes; that the finger of science now clearly points to the means, and reason should not longer hesitate to obey the salutary dictates.

3. In a paper, inserted in the *Mechanics' Magazine*, for June, 1831, I suggested an improvement in the means of lighting towns, by the substitution of a powerful oxyhydrogen-lime light, to be placed at a great altitude above the surrounding buildings;—for example, on the summit of a church-tower, or upon an elevated turret, to be purposely erected in lieu of a multitude of inferior lights from carburetted hydrogen, scattered here and there about the streets and avenues. Seven years after, M. Gaudin proposed the same thing, under the designation of *artificial suns*, to illuminate the city of Paris. It is probable, nay, almost certain, that M. Gaudin had no knowledge of my anterior project; and it is beyond doubt, that neither his proposition nor my own have ever realized sufficient attention to render such a plan operative, although obviously practicable without difficulty. Even before the period to which I have alluded, but much more frequently since, several of my scientific friends will remember that I have repeatedly advocated the practicability, as well as the vast superiority, of a system of public illumination dependent on electric agency; nor have I regarded the means to be thus called into operation as less applicable to *stationary lights* in public edifices or private dwellings. In several instances I have experimentally demonstrated the applicability of this principle to private uses; and it proved no small gratification to me, when the scientific journals, in the early part of the current year, announced some particulars of a successful experiment of this description which had been made in Paris, in the Place de la Concorde, in the autumn of 1843.*

4. What was wanting, however, in my own experiments to insure the successful adoption of electrical lights by the public, seems equally requisite in the Parisian experiment, viz., *economy* of the means to be employed, and a perfect command over the *permanency* of the electric current on all necessary occasions.

5. It is needless, in the present state of science, to show how intense degrees of voltaic light, such as is required for the purpose in question, may be produced, but it is equally

* Vide *Elect. Mag.* vol. i. p. 312.

Digitized by Google

obvious that all our means hitherto in use would involve too great an expenditure of time and materials, independent of skill in various manipulations. These considerations have formed the stumbling-block, and defeated the issue, of all my previous researches with a view to realize the great desideratum to which I dedicate the present earnest suggestions.

6. As I have in substance already remarked, the possibility of applying electric currents to the purpose of public illumination must long since have been self-evident to philosophers; it was in the *working* details alone of such a scheme that the deficiency of our means became manifest. Fortunately, as I conceive, our difficulties have at length vanished; I feel the strongest assurances of ultimate success, while neither economy of means, permanency of action, nor adequacy of effect will be denied to the result of our efforts. Let us now endeavour impartially to examine the few elements which should constitute the system we would propose for adoption; and, in the first place, it may be well if we take a brief survey of that which has been already accomplished in the production of light from electric currents.

7. Many years since Mr. Children constructed a most formidable description of battery, consisting of twenty pairs of copper and zinc, each plate of which was six feet by two feet eight inches. With this apparatus, great lengths of thick platina wire were ignited, and even those refractory bodies iridium and osmium were readily fused. If, to the extremity of each conductor from this battery, when its cells were properly charged, pencils of box-wood charcoal were attached, and their points brought together, splendid combustion of the charcoal would take place, and if the points were then slightly withdrawn from each other, a brilliant display of flame would be kept up between them, the duration and intensity of which would be necessarily regulated by the amount of electrolytic action exercised in the cells of the series.

8. With the extensive battery of the Royal Institution, consisting of 2000 pairs of four-inch plates, Sir H. Davy, as is well known, caused a voltaic flame between charcoal points to play through four inches of the heated air, and within an exhausted receiver the space occupied by the flame was much longer. Here, however, let us remark, that although the charcoal points may be drawn further asunder in attenuated air, and the length of the flame thus increased, *the intensity of the light is very materially lessened by this condition.*

9. Professor Hare, of Philadelphia, by means of his powerful battery of 300 pairs, which he denominates a "defla-

Digitized by Google

grator," has produced a light from charcoal so intense *that it had the appearance of sunshine on some adjacent buildings on which it fell.*

10. Professor Daniell has shown that by means of one of his constant batteries, consisting of seventy cells, in a single series, a voltaic flame of considerable volume forming a continuous arch, and emitting light of great intensity, is produced between charcoal points. In these experiments such, indeed, was the intensity of the light, that it proved highly injurious to the eyes of the spectators, although they were protected by grey glasses of double thickness. A friend of my own, who had the satisfaction to witness some of Mr. Gassiot's elegant and brilliant experiments in voltaic electricity, experienced therefrom analogous effects, which in his case produced severe inflammation of the eyes.

11. With a Grove's battery of forty pairs, M. de la Rive succeeded in obtaining a luminous arch of the most beautiful light an inch or more in length; and with a more extensive arrangement of professor Grove's platina battery, and also by means of other magnificent combinations, Mr. Gassiot has produced the most splendid results, by gradually withdrawing from each other the charcoal terminals of his batteries after they were in action, although neither spark nor flame could be elicited until the circuit had been first completed; and this condition holds good in all similar experiments. It is, however, a fact which I have witnessed, that my friend Mr. Crosse with a *water battery* of 2400 pairs of four-inch plates, rarely fails to produce not only a spark, but a stream of light, between platinum wires not having previously been brought into contact. We may revert to this important fact in our future considerations.

12. Several other very brilliant experiments, tending to illustrate the employment of voltaic currents as a means of producing intense light, might be enumerated, but the examples already given are sufficient for the occasion. I shall therefore simply mention, that with a platina and zinc battery of eight pairs only, somewhat peculiarly arranged, I have succeeded in keeping my laboratory—a large room nearly fourteen feet square and about seventeen in height—steadily and sufficiently illuminated for useful purposes, during many hours, and this by means *of a mere speck of brilliant flame* playing between gas carbon points connected with the conducting wires of the apparatus. It may possibly be worth while also to mention, that the same room experiences throughout a soft and pleasing illumination, nearly equal to that of the full moon, from a current of electricity passing through a series of eight rotating electro-magnets, grouped in con-

Digitized by Google

nection with each other, and communicating with a pair of twelve-inch plates of zinc and copper, separated by a bladder diaphragm, and supplied respectively with solutions of sulphate of copper and common salt. It will readily be understood that the light evolved in this case, is owing to the incessant occurrence of vivid sparks dependent on the numerous and frequent breakings of contact, caused by the septums which divide the mercury dishes, over which the several temporary magnets revolve with great velocity. A brilliant circle of light is thus presented permanently to the eye, from each magnet of the series. Extensive groups of this description advantageously arranged might have their uses in illuminating apartments, &c., as they are neither expensive nor troublesome to work, but they are not calculated to meet the design contemplated in our present suggestions.

13. The preceding retrospect of experimental facts, while it serves to exhibit the certainty of success with which electric currents might be employed to furnish the means of artificial illumination, would also, were we to enter upon a calculation of the requisite expenses in material and time occupied in manipulations, &c., essential to practical results, tend equally to prove the operative principle eminently deficient in those grand points of simplicity and economy, which must constitute the main features of such an important undertaking. Let us, therefore, inquire what amount of *natural resource* the wand of science can summon to our aid on this occasion.

14. Not only is the atmosphere by which we are surrounded the medium of continual electric action, but it is now satisfactorily proved, that the earth itself *is a conductor and a permanent generator of voltaic electricity.* In other words, the moisture ordinarily contained in the earth may be advantageously employed as an exciting liquid to heterogeneous metals and other electrics. A single pair of dissimilar metallic plates buried a few feet beneath the surface, and connected with machinery of singular simplicity, become at once the ready and always obedient heralds of our thoughts and wishes, to the abodes of those who are located some fifty or a hundred, nay, it may, under suitable arrangements, be thousands of miles distant; and this, too, with a speed that rivals at least the fiery messengers of the storm. Professor Morse, Mr. Bain, and a few others, have already availed themselves of the merits of this new and beautiful discovery, by ingenious applications of the subterraneous currents to their several purposes. Professor Morse has indeed, by his able researches, recently added several new and highly important facts to our stock of knowledge in this interesting department of science; but of these I do not feel myself yet at liberty to

Digitized by Google

speak more freely. I have myself also engaged in many experiments on this source of electric action, and from these researches, and by their comparison with the labours of others, I think I am entitled to consider the following facts as established:

15. When a pair of dissimilar metallic plates, zinc and copper, or zinc and iron, for instance, are buried in the earth, as in some late experiments in Hyde Park, made public by Mr. Bain,* and the two are connected by a wire, whether they be placed in the vicinity of each other, or miles of solid earth are permitted to intervene, a voltaic current is established, and certain electro-chemical and electro-magnetic phenomena will obtain between the extremities of the respective conducting wires or electrodes; *and this action will continue for an indefinite but very long period of time;* that is to say, until one of the metals of the pair or series has undergone complete decomposition.

16. Notwithstanding that electricians are fully aware that the amount of chemical and some other effects to be sought from a voltaic current must be calculated upon the *number*, and not upon the *size*, of the plates employed to generate the current, the former representing *intensity* and the latter *quantity;* yet to those who have not carefully and minutely attended to the fact, the assertion may perhaps appear startling, that a certain degree of chemical decomposition (no matter how trivial the result may be), and that independent of the use of any species of condenser, does take place in fluids between the electrodes of every subterraneous pair, provided it presents at least surfaces of 136 superficial inches, and under certain conditions less would suffice, although the *immediate* effect is generally invisible. It is true that such decompositions take place with singular tediousness, and in most instances the resulting products are minute in quantity; but by such means alone have the gaseous constituents of water been set free, the solutions of salts transferred, and the colour of vegetable infusions changed, &c.

17. Early in the spring of the present year (1844), I buried in my garden a pair of plates, which consisted of parallelogram sheets of zinc and iron, about the thirtieth of an inch in thickness, each plate presenting a surface of six superficial feet, being respectively three feet in length and two in the opposite direction. These plates are deposited in a vertical position, three inches apart, and four inches beneath the surface of the ground, which is a rich mould containing a large portion of decayed vegetable matter, carbon, in a finely divided state,

* *Vide* Elec. Mag., No. 1, p. 50.

Digitized by Google

and other adventitious substances. Conducting wires thirty feet in length, and carefully insulated on glass supports, convey the current from this subterraneous pair to a table inside my laboratory window, in conjunction with a delicate galvanometer and other apparatus. It must now be mentioned that the spot, owing to its elevation and other local circumstances, is peculiarly dry, and by no means subject even to the ordinary moisture incident to soils of this character. At the time these plates were deposited in the garden, no rain had fallen for many weeks previously, and the condition of the surrounding earth was that of *extreme natural dryness;* yet the instant after the conducting wires were brought home and attached to the galvanometer, and this was as soon as the plates were covered with the soil, the astatic needle flew violently round to 87°, and after three minutes settled to a steady deflection of 61°. The current from these plates up to the present moment (November 10th) is, to speak generally, remarkably uniform; but certain interesting changes, *independent of moisture alone,* as shown by the galvanometer, have been occasionally noticed, and these are receiving attention, although it is not needful in this place to mention further particulars, except to state that experiments have shown that the changes alluded to are not in accordance, as might be supposed, with differences of temperature.

18. With the ends of the conducting wires from the buried plates (17) were connected two other wires of platinum, the 16th of an inch in diameter; these latter, after passing through corks to fix them, descended into a V tube of glass, until they approached within five-tenths of an inch of each other, near the angular bottom, the tube being carefully cemented on to a glass foot stand which kept the little apparatus steady. Before completing the connection of the V tube with the plates, the former was charged with a watery infusion of red cabbage, in which a few crystals of sulphate of soda had been dissolved. After four days, the blue infusion in that branch of the tube corresponding with the zinc side of the buried plates had begun to assume a deep red, showing that a decomposition of the salt in solution had taken place, and its constituents were being transferred, agreeably to their electro-polar dispositions. A series of curious phenomena, in regard to the changes of colour in the infusion, went on with remarkable tardiness during fifty-four days, but I will not detail them here; what I desire more particularly to mention is, that on the eleventh day of the experiment, an accumulation of extremely minute air-bubbles appeared at the top of the fluid in each branch of the tube, immediately under the corks serving to hold the platina wires, and close to the respec-

Digitized by Google

tive openings. On the 12th day I perceived that the bubbles were increased, and at the top of the fluid surounding the negative wire *their volume was twice the amount of that which had collected on the opposite side.* Still no gas in the act of being liberated from the fluid could be seen until I applied a good lens, and then *a multitude of exceedingly minute gas bubbles* were clearly detected as they escaped at places all over the surface of the platina wires. On reaching the top they united to form the groups of larger bubbles which had previously attracted my notice. I watched this experiment scrupulously during many days, and if there be certainty in any thing, it is certain that the gaseous elements of the water were set free in this experiment.

19. Other experiments by means of different series of buried plates have shown, in accordance with previously known laws, that the intensity of the electric current is enhanced by increasing the number of the pairs; yet, where the plates of such combinations are small, the current proves feeble comparatively, notwithstanding the number may be considerable; but when larger surfaces, for instance, metals presenting from one to two or more feet superficial each, are combined to the amount of some twenty-five or thirty pairs, both the chemical and other effects become important. However, if a pair of very large plates, the current from which might be one of low tension, were to be greatly subdivided, a plate containing twelve superficial feet, for example, being cut into forty-eight equal portions, and these portions being connected by bands or wires, *so that they were grouped into one source of action,* each plate of the subdivision being placed beyond the radius of influence exerted by its fellows, then an immense increase of power is gained, and the *further increase* of this power seems to be in the ratio of an augmentation of the number of the groups.

20. The general energy of subterraneous combinations may be inferred from the ascertained effects of a series of very small plates arranged in the ordinary way and immersed in a wet earthy medium having tenacity and adequate consistence. In the autumn of 1843, I prepared fifty pairs of copper and zinc plates, each three inches in length and one in diameter: they were united into pairs by a short copper band, which, when bent twice at right angles in the same direction, caused the plates to assume a parallel direction a quarter of an inch distant from each other. A wooden trough eighteen inches in length, four deep and three in breadth, was filled with what is here known by the name of "haven mud," taken from the bed of a tidal river called the *Stour.* Into this

Digitized by Google

medium the plates were plunged in a double row, and a quarter of an inch apart from each other; and being furnished with the usual conducting wires, they served for many months to effect various decompositions, as water, preparations of iodine, metallic and saline solutions, &c., which took place in a slow and uniform manner. The galvanometer, as might be expected, was but slightly affected by this arrangement, which I designated a *mud battery*. The apparatus is singularly portable and convenient, and it only required that the mud in the trough should be slightly wetted occasionally with water from the Stour to keep it in constant action for an indefinite period. However, it was at length taken to pieces, when the plates, contrary to expectation, were found very little changed. Both in simplicity and effect the apparatus may be compared to a *water battery*, and it reminds one in some respects also of the constant battery of Prince Bagration, since described in *L'Institut.—Feb. 22nd*, 1844.

(21). The following are a few of the practical results to be derived from a series of thirty-six pairs of sheet zinc and iron plates, each two feet in depth, and three feet long, and consequently containing six square feet; the total surfaces therefore amounting to 432 square feet. These plates were buried vertically, half an inch apart, and sixteen inches under ground, in a loamy soil, possessing no more than the usual degree of moisture, and were arranged so as to avoid all cross action, agreeably to the plan of Mr. Roberts's blasting battery.*

1. Water without the addition of sulphuric acid is decomposed, and yields an uniformly continuous stream of the mixed gases visible many feet from the apparatus.

2. Electrotype operations are effected with far too great a degree of rapidity, the character of the copper deposit being spongy and deficient in cohesion.

3. The reduction of metals from their solutions takes place speedily in singularly beautiful arborescent forms.

4. A large rotating Ritchie's magnet revolves with great rapidity, producing a loud hum and a continuous circle of vivid light over mercury.

5. The sustaining powers of electro-magnets are freely developed in proportion to their respective capacities.

6. When the conducting wires are attached to a small electro-magnetic coil machine the shocks produced are insupportable.

7. A small, but exceedingly brilliant, spark takes place when the conducting wires are brought into contact and separated.

* Vide *Proceed. Electrical Soc.*, p. 356.

Digitized by Google

8. A speck of *intensely vivid light* is constantly exhibited between fine gas carbon points very slightly separated after perfect contact.

(22). What remains to be suggested is reducible to a small compass. It is obvious, that if from a series of buried plates, such as I have described, a speck of intense light can be produced, which will enable one to read small print at a distance of nearly eighteen inches from the carbon electrodes, then ten, fifty, a hundred, a thousand, or ten thousand times as much light may also be produced by similar arrangements, multiplied and regulated in the ratio of the desired effect. Hence I arrive at what now seems to be a self-evident conclusion: *that it is practicable to illuminate our public streets, edifices, and even private apartments by means of electric currents derived from subterraneous voltaic batteries.* It might reasonably be expected of me, after this declaration, that I should be able to furnish the details necessary to bring the suggested plan into operation. I think I need not enter on minutiæ; a general outline seems all that is essential to the immediate occasion.

1. As regards street illumination, the number of lights being determined, a hollow pedestal, surmounted by a pillar of sufficient height, in most respects similar to the cast iron lamp posts ordinarily employed for gas-lighting, should be erected at each station; and around each pedestal, at the depth of a foot or eighteen inches beneath the surface of the earth, should be buried a voltaic battery, consisting of several thousand pairs of plates, arranged as in our last-mentioned experiment (21).

2. It would seem desirable that the plates constituting each battery series should be deposited vertically around each station, in the form of a narrow ellipsis, the respective ends terminating near to, and one on each side of, the hollow pedestal, within which, properly defended from contact, the conducting wires might ascend into a glass globe fitted for the reception of carbon points, from which the voltaic lights are to proceed.

3. Under all considerations, the best and most durable material for exhibiting voltaic light appears to be gas carbon. Small cylinders of this substance, three or four inches in length, and perhaps the tenth or twelfth of an inch in diameter, formed like the *leads* (plumbago) of the "ever-pointed pencil," might be advanced towards each other, and withdrawn at pleasure, through hollow metallic cases, opposed to one another, and passing through the sides of the glass globe, outside of which their *distance within* might be regulated by

Digitized by Google

means of a very simple mechanical contrivance. The globe itself should be screwed on to the top of the pillar, from which it might be readily detached for the purpose of occasionally renewing the carbon points, &c.

4. In as far as experiments have yet determined, the use of copper as a negative metal ought not to be adopted; while it seems that iron may be substituted, as being not only more economical, but at least equal, if not superior, in effect; or, probably, M. Bunsen's prepared carbon plates* might be found more advantageous than either copper or iron. One of the principal features of recommendation in a subterraneous battery is the uniformity of its action. To the duration of the positive metals there must necessarily, however, be a limit; but if they were at first deposited of considerable thickness, suppose five-tenths of an inch for instance, so slow and regular is the rate of their action, that a battery might reasonably be expected to continue in operation through many successive years.

5. It does not appear difficult to keep the glass globes, suggested to contain the voltaic lights, exhausted of air, as is said to have been the case in the late Parisian experiment, performed by the aid of two hundred carbon and zinc elements, excited with nitric acid on one side, and sulphuric acid diluted on the other; but the advantages of exhaustion, if any, would be more than counterbalanced by extra expenses in apparatus and attention.

6. It were, perhaps, possible to furnish a vast number of voltaic lights within a district with an adequate current of electricity from a single battery upon an enormous scale, as gas lights are supplied from a single reservoir; but in this way the passage of the current would be much more liable to derangement, without its being so easy to discover in what part of the conductors the injury or defect had taken place. A battery appropriated to the production of each light seems the more eligible plan; and, upon a rough estimate, it does not appear that the primary arrangements of the voltaic system would exceed, if indeed they would equal, the first outlay of a gas manufactory, its main and branch pipes, &c., and when once complete, the expense of the voltaic lights would amount to a comparative fraction.

7. The foregoing observations, it may be presumed, will sufficiently illustrate the practical application of the few principles advocated in this paper, which I will conclude with an additional remark. Let subterraneous batteries, each

* Vide *Electrical Magazine*, No. I., p. 16.

Digitized by Google

composed of some eighty or a hundred thousand pairs of voltaic plates, be formed around our principal lighthouses, with conductors to convey the electric current to a suitable apparatus on the summit of the respective structures—its cost, in a national point of view, would be insignificant—and then we might hope to produce a beacon worthy of being called "*the light of all nations.*"

Sandwich, November, 1844.

LXXXVII. — *Magnetic Note.* By Charles V. Walker.

Captain Ibbetson had mentioned to me some experiments which he had witnessed at Birmingham, immediately after the meeting of the British Association at York, wherein musical notes were obtained from a long iron bar constituting the core of an electro-magnet every time contact was made or broken. I afterwards read Mr. Marrian's account in the *Philosophical Magazine*, for November last; and on the same day was present in Professor Grove's Laboratory at the London Institution, where they were repeated, and of which a notice is given in the *Literary Gazette* for Nov. 2. I have repeated them with Mr. Watkins and Mr. Brooke, the former of whom, the editor of the *Literary Gazette* very truly describes as "being ever ready to place his apparatus at the disposal of the amateur." They have been repeated by Mr. Bachhoffner at the Polytechnic Institution. They had also been confirmed by experiments at Oxford, and at King's College, London.

The sum of the phenomenon is that, during the act of sudden magnetization, a bar of iron or steel gives forth a musical note, which is the tonic of the bar when struck endwise, or producing longitudinal vibrations; and that, during the sudden cessation of magnetization, it gives forth the same notes. The note on *breaking* contact is the *louder* of the two. The pitch of the note depends greatly on the mode of resting the bar, and varies according as it rests on the coil, on chair-backs, on cushions, or from cords. Mr. Brooke rested the long bars on their nodal points, and the sound was improved. According to the nature of the bar, and the power employed, the sound is heard by applying the ear close to the end; or it is distinctly heard in any part of the room, like the striking of a repeater. Mr. Grove applied an extemporaneous substitute for a sounding-board, and this greatly exalted the pitch, and led to the conclusion that the note might be made audible throughout the lecture-room, by mounting the bar on a true sounding-board.

Digitized by Google

This musical note, is not, however, so new as we had imagined; for an incidental mention of it had been consigned to the *Annals of Electricity*, March, 1842,* by Mr. Joule, in the following words:—

"When one end of the electro-magnet is applied to the ear, a distinct musical sound is heard every time that contact is made with or broken from the battery."

The followings extracts from letters I have received from Mr. Weekes, show that it has been publicly known abroad as well as here, although a different core was used:—

"Within a coil, insert a piece of *thin* sheet-iron rolled loosely up, both edges together, but without actually touching. Make and break the connection of a current from a strongish single pair, passing along the coil; and at every break the soft iron emits a sound a little more agreeable than the ticking of a clock. The apparatus by which this experiment was originally made, consisted of a glass tube about an inch and a half wide and a foot in length, with a thick helix wound round it. Whether it was more musical in that way I do not know." Nov. 25th 1844.

"The experiment, of which I gave you a rough account on *sound*, was first made known to me in a letter, sent from Washington by Mr. Lettsom, in the summer of 1843, but without any information as to its author. One thing I can say for *certain*, I have often repeated the experiment with success." Dec. 3rd, 1844.

Thus much of the experiment and its history; one thing it demonstrates that the magnetic conflict produces an actual mechanical vibration of the particles of iron in the direction of the length of the bar, or at right angles to the voltaic current. It is a known fact to all who have experimented with continuous voltaic currents, as in electrotype operations, that the annealed copper wire, with which we begin, finishes after having been long traversed by the current, in becoming exceedingly brittle. Connected with the magnetic note, does not this imply that a mechanical vibration and re-arrangement of the metallic particles occurs equally in this case? What would be the result of using a soft iron core for a long time? would it eventually acquire somewhat of the character of cast-iron and be brittle? Is this phenomenon in any way connected with the fracture of the iron axles of railway carriages? I merely give these as passing hints: I must not, however, conclude without mentioning that Mr. Marrian has put forth the idea that as the electrical current produces this note in mechanical vibration, the converse is highly probable, that the mechanical vibration or note would produce electricity. This would, indeed, be a beautiful illustration of Grove's Correlation of Forces. C. V. W.

* *Vide* Vol. viii. p. 222.

Digitized by Google

SCIENTIFIC MEETINGS.

Additional Researches on the Electrolysis of Secondary Compounds. By J. FREDERICK DANIELL, Esq., D.C.L., For. Sec. R. S., Prof. Chem. King's College, London; and W. A. MILLAR, Esq., M.D., Dem. of Chem. King's College, London. Read Feb. 25.—From Phil. Trans. for 1844. Part i. p. 1.

(EXTRACTS.)

A REPORT of this paper was given in *Elec. Mag.* No. 5, p. 381; we now propose that the authors speak chiefly for themselves. After the introductory observations, we read:—

"Our first object was to ascertain more clearly than had yet been done, the influence of water in the aqueous solution of an electrolyte, by comparison with the results of the electrolysis of the same compound when in the state of igneous fusion. It had been already determined that, with regard to the *chlorides*, no difference occurred, and that the amount of chlorine evolved in the same circuit from *fused* chloride of lead, and from dissolved chloride of sodium and muriate of ammonia, were the same. In the last case, ammonia and hydrogen were evolved at the platinode* in equivalent proportions to the chlorine at the zincode. Here a compound cation ($N H_4$) was separated from an elementary anion.

"When *nitrate of silver* in solution is subjected to electrolysis, the simple cation, silver, separates from the compound anion ($\dot{N} O_6$); and upon substituting the *salt in a state of fusion* for the solution, we obtained the same result. No gas was evolved; but *crystallized metallic silver* was deposited upon a silver platinode, which gradually increased in length, as it was slowly withdrawn from the liquid salt, just as in the analogous experiment with fused chloride of silver, devised by Dr. Faraday. Nitrous fumes were at the same time given off from the platinum zincode in abundance. From these experiments it is evident that neither the grouping of a compound cation, nor of a compound anion, is necessarily altered by water in the transit to their respective electrodes."

The authors now turned their attention to the interesting group of salts—*the phosphates*. In their experiments they employed a *double diaphragm cell*, for containing the subjects of electrolysis: it was a horizontal cylinder formed in three parts; the middle cell being separated from each extreme cell by a membrane diaphragm; each of the extreme cells contained a platinum electrode, and was furnished with an escape-tube, for collecting the gases evolved.

"A strong solution of *tribasic phosphate of soda and water* ($2 Na O, H O, P_2 O_5$) (rhombic phosphate) was placed in the platinode cell of the diaphragm apparatus; the centre cell and the zincode cell were both charged with a dilute solution of soda ($\frac{1}{18}$). The power of 20 cells of the small constant battery was transmitted through it; and in 37 minutes, 48 cubic inches of hydrogen were collected from the platinode; the experiment was then stopped, and the solutions examined.

"The liquid from the zincode cell was carefully neutralized with nitric acic; and then gave a copious yellow precipitate with nitrate of silver, soluble in nitric acid, and in ammonia, the well-known characters of the tribasic phosphate of silver ($3 Ag O, P_2 O_5$,). The solution in the platinode cell had become much more alkaline than at first; but, when neutralized with nitric acid, gave a similar yellow precipitate with nitrate of silver. There could be no doubt, therefore, that *tritoxyphosphion* (or the radicle of the trito-hydrate of phosphoric acid) had travelled to the zincode."

* *Platinode*,—cathode, negative electrode; *zincode*,—anode, positive electrode.—*Ed. Elec. Mag.*

Digitized by Google

The *tribasic phosphate of soda* ($3\,NaO, P_2, O_5$), (sub-phosphate), and *the phosphate of soda, ammonia and water* ($\left.\begin{matrix}Na\ O\\ NH_4\ O\\ H\ O\end{matrix}\right\} P_2\ O_5$) (microcosmic salt), each in solution were in turn operated upon, and the result tested in a similar manner; the yellow precipitate from nitrate of silver was produced in both cases, "proving that it was the tribasic salt, which had travelled, as before."

"A similar arrangement was made with a solution of *dibasic phosphate* (pyrophosphate) of soda ($2\,Na\,O, P_2, O_5$). Hydrogen and oxygen in equivalent proportions were respectively given out at the platinode and zincode, and the process was carried on to the same extent as before. The solution at the zincode after electrolysis was neutralized by nitric acid. When tested with solution of nitrate of silver, a copious white precipitate was formed, indicating that, in this case, *deutoxyphosphion* (or the radicle of the deuto-hydrate of phosphoric acid) had been transferred to the zincode.

"A solution of *monobasic phosphate* ($Na\,O, P_2\,O_5$) (metaphosphate) was subjected to electrolysis under the same circumstances. The solution in the zincode cell was now found to be strongly acid instead of alkaline; when added to a solution of albumen, it immediately coagulated it; and with nitrate of silver, and nitrate of baryta, it produced the characteristic gelatinous white precipitates, which are distinctive of the monobasic phosphates of those bases."

The inference drawn by the authors is, "that the three hydrates of the phosphoric acid constitute three essentially distinct acids;—and that, when disengaged from their corresponding saline compounds, they travel as three distinct *oxyphosphions* in the circuit." Graham's theory of the phosphates and of the basic character of water is also confirmed.

Solution of *tribasic arseniate of potassa and water* ($K\,O, 2\,H\,O, As_2\,O_5$) (binarseniate) was now electrolyzed in the platinode cell; the other cells containing solution of potassa. No arseniuretted hydrogen nor metallic arsenic was liberated; but the zincode solution, when neutralized with acetic acid, and tested with nitrate of silver, gave the "characteristic brick-red precipitate of the arseniate of silver ($3\,Ag\,O, As_2\,O_5$); so that there could be no doubt that the *tritoxarsenion* had travelled into the zincode cell."

Salts, having the same radicle as those above, but in a less degree of oxygenation, were next examined.

Arsenite of potassa ($K\,O, As_2\,O_3$) in one cell and solution of potash in the others, gave off metallic arsenic at the platinode, and oxygen at the zincode; the solution of the latter, when neutralized by acetic acid, and tested with nitrate of silver, gave a yellow precipitate of silver. In this case,

"It might have been anticipated that the oxygen, in travelling with the arsenious acid to the zincode, would have combined with it, and formed a portion of arsenic acid; but no such result took place: and, it must be remarked, that two equivalents of oxygen, instead of one, would be required fully to oxidate the whole. We must, therefore, conclude that $As_2\,O_3 + O$ constitute what we may for the present distinguish as a *sub-oxarsenion*."

With respect to other salts;—

"The *carbonates* and *oxalates* may be compared together in the same point of view as acids of the same radicle in different states of oxygenation.... We found that, although in the electrolysis of oxalate of ammonia ($C_2\,O_3 + O$) was always exactly evolved, yet that it was not invariably in the form of carbonic acid, but in

Digitized by Google

different proportions of oxalic acid with free oxygen and carbonic acid. It was thus proved that the burning of the oxalic acid into carbonic acid by its associated oxygen was a secondary process; and that the ($C_2 O_3 + O$), which travelled in the circuit, was in some way different from 2 ($C O_2$)."

With the *sulphates* it had previously been shown that sulphuric acid + oxygen travels to the zincode; with the *sulphites*, there was sulphuric acid but no oxygen; from analogy, it was probable that sulphurous acid + oxygen travelled, and that they combined to produce the sulphuric. *Hyposulphite of soda* produced analogous results. The authors then proceeded to determine the exact relations of the *yellow and red ferro-cyanides of potassium.* After stating the two views that have been maintained of the constitution of these salts, and referring to Mr. Porrett having determined long ago that the iron accompanies the cyanogen in the electrolysis of salts of hydro-ferrocyanic acid, Mr. Smee's experiments of converting the yellow into the red salt by electrolysis, are noticed; but the authors do not agree with Mr. Smee in believing that the reduction is due to *nascent oxygen.* They repeated Mr. Smee's electrolysis of the *yellow ferro-cyanide.* The phenomena were, —pure hydrogen at the platinode, equivalent to that in a voltameter, included in the circuit; and the platinode solution became paler and alkaline; — the zincode solution became red, after a time oxygen was given off; it then became green and acid, and the zincode was covered with a film of Prussian blue; red ferro-cyanide was obtained by evaporation; only a small quantity of the yellow salt remained in solution.

"The explanation of these results is, we think, sufficiently obvious. Ferro-cyanogen was doubtless transferred to the zincode, and potassium to the platinode; the former combined with a portion of the ferro-cyanide to form the subsesqui-ferro-cyanide; the process being accelerated by the abstraction of a portion of the potassium passing over to the platinode, where, by its reaction on the water of the solution, it was converted into potassa with the evolution of hydrogen. As the process proceeded, more ferro-cyanogen was given off at the zincode than could be absorbed by the yellow salt; and it consequently began to react upon the water, becoming converted by the abstraction of its hydrogen into hydro-ferro-cyanic acid, its oxygen being evolved. The acid reaction is thus accounted for, as well as the deposition of Prussian blue, from the well-known spontaneous decomposition of the acid."

Solution of the *red* salt was now electrolyzed; and that portion in the platinode cell gave off hydrogen, and was converted into the *yellow* salt.

"Could a doubt remain with regard to the conclusion to be derived from these experiments, it must be removed by the results of the following arrangement. The zincode cell was filled with a dilute solution of potassa, and the connecting cell with the same. The platinode cell was charged with a strong solution of the red ferro-cyanide. This solution, previously to the commencement of the experiment, gave no blue solution with perchloride of iron. The liquid in the zincode and connecting cells speedily became yellow: and, after a short time, the solution in the platinode cell also became yellow. All the solutions were now found to contain the yellow ferro-cyanide. Thus, it was quite clear that no such compound as ferrid-cyanogen ($Fe_2 Cy_6$) travelled from the red salt, when exposed to electrolysis; but that the red salt was converted into the yellow by the abstraction of ferro-cyanogen from the platinode, which ferro-cyanogen, being transferred to the zincode, there formed, with the potassium, presented to it by electrolysis, the same yellow ferro-cyanide."

Digitized by Google

With *cyanide of potassium* (K, Cy) in the platinode cell, and solution of potassa in the other cells, hydrogen was given off in the former, by the deoxidizing action of the liberated potassium; and oxygen at the zincode, by the deoxidation of the potassa to form the cyanide of potassium, which was found there abundantly. With *cyanide of potassium* throughout the diaphragm cell, hydrogen, as before, came from the platinode, and the zincode solution became deep brown, and also contained hydrocyanic acid. The brown matter was supposed to be *paracyanogen*. On charging the whole with *sulphocyanide of potassium*, a copious orange-coloured deposit occurred in the zincode cell; from which "there could be little doubt that *sulphocyanogen* was the anion transferred in this experiment."

A new order of phenomena now presented themselves, which the authors turned aside to examine. They had hitherto been transferring the acid of the phosphates from the platinode cell to a base in the zincode cell; they inverted the order, by passing a base from the zincode to an acid at the platinode.

"Some pure *sulphate of potassa and copper* (Cn O, S O_3 + K O, S O_3) was carefully prepared, and its solution placed in the zincode and connecting cells of the diaphragm apparatus: the platinode cell was charged with dilute sulphuric acid, the current of 20 cells of the battery was transmitted through the arrangement until 48 cubic inches of hydrogen had been collected from the platinode, and 23·5 cubic inches of oxygen from the zincode (about one equivalent in grains,) when the process was stopped. The platinode solution was perfectly colourless with a very slight deposit of copper upon the platinode, amounting only to 0·1 grain. It was evaporated to dryness in vapour of ammonia, and the residue was perfectly white sulphate of potassa, which weighed 21 grains. It was entirely soluble in water: and ammonia did not produce the slightest blue colour in its solution. The liquids of the zincode and connecting tubes together required 51 grains of dry carbonate of soda to neutralize the free acid. Now, it will be observed, that the sulphate of potassa was only one grain less than a quarter of an equivalent, which, considering the nature of the processes by which these quantities were determined, will appear a very near approximation; and we may take the results of the electrolysis to have been as follows:—For one equivalent of force as measured by the gases evolved at the zincode and platinode, half an equivalent of oxysulphion of potassium (sulphate of potassa) was decomposed (as measured by the quarter equivalent potassium transferred) and half an equivalent of oxysulphion of hydrogen (aqueous sulphuric acid): for it will be observed as most remarkable, that the quantity of copper transferred was perfectly insignificant.

"Upon the view of the principle of electrolysis hitherto commonly admitted, viz., definite decomposition with equivalent and opposite transfer of the elements or radicles of the compound to the opposite electrodes of the battery, these results were sufficiently perplexing: but our perplexity increased as we proceeded; and it was not till after we had expended an incredible amount of labour in testing different hypotheses of various resistances and opposing forces, supposed to be developed in these complicated cases, that we thought of questioning the principles themselves."

Sulphate of alumina and potassa (alum) produced similar results; the platinode cell was found to contain within a grain a quarter of an equivalent of sulphate of potassa. With *sulphate of magnesia and potasssa*, analogous results were obtained; but only about $\frac{1}{12}$th of an equivalent of magnesium passed to the platinode.

"Thus it appeared that the three bases, alumina, magnesia, and oxide of copper,

Digitized by Google

or their metals, when in combination with sulphuric acid and potassa, refused to travel from the zincode to the platinode under the influence of the voltaic current into an acid with which they were capable of forming an immediate and soluble combination. Could it be that the same results might follow from the electrolysis of the single salts of the same acid?"

On charging the zincode and connecting cells with a solution of pure *sesquisulphate of alumina*, and the platinode cell with aqueous sulphuric acid, and electrolyzing it for half an hour, not the slightest possible trace of alumina was found in the latter cell.

"Thus it again appeared that the electrolysis was carried on without the transfer of the base or its metal to the platinode. Was the peculiar constitution of this salt as a *sesqui* compound concerned in any way in this result?"

Sesquisulphate of iron was treated exactly in the same way; but no sesquioxide of iron appeared near the platinode.

"We next tried salts of the more ordinary constitution of single equivalents of acid and base. The zincode and connecting cells were charged with solution of *sulphate of copper* (Cu O, S O_3), and the platinode cell with dilute sulphuric acid. The combination conducted well; 23·6 cub. in. of oxygen were collected from the zincode, and an equivalent of hydrogen from the platinode; but the platinode plate was scarcely covered with a very thin film of copper, the metal not having been transferred in any considerable quantity. Upon neutralizing the solutions on the two sides by carbonate of soda, it was found that an equivalent of sulphuric acid had travelled to the zincode. Upon reversing the arrangement, oxygen was collected as before from the zincode, and an equivalent of copper was thrown down upon the platinode, but no hydrogen was evolved."

Solution of *sulphate of potassa* was substituted for the dilute sulphuric acid of the above experiment, and analogous results followed.

"Thus it appeared that copper refused to exchange places with potassium in the circuit, as it had before refused to exchange with hydrogen, and so to pass from the zincode to the platinode."

Sulphate of zinc under similar treatment gave analogous results.

"To ascertain whether the passage of the current from one electrolyte to another was in any way concerned in preventing the transfer of the base, we now resolved to employ *sulphate of copper* in solution, *throughout* the whole arrangement; and, having carefully ascertained the proportion of copper in solution, we placed 1500 grains of the liquid in each cell; metallic copper was thrown down on the platinode; and, in precipitating the oxide from the liquid in the cell by potash, we found exactly the same amount of copper (taking the united quantities obtained from the oxide precipitated and the metal deposited) as before the experiment. An equivalent of sulphuric acid was set free at the zincode, but the quantity of the copper solution in the cell continued the same as at the commencement. Copper thus appeared to refuse to exchange with itself in electrolysis. *Sulphate of zinc* afforded results exactly similar."

Membrane diaphragm was exchanged for porous earthenware with the same results; and even without a diaphragm, when strong solution of sulphate of copper was electrolyzed in a U tube with copper electrodes.

"After a long time the liquid in the platinode limbs of the apparatus became sensibly lighter coloured, while that in the zincode became darker; the oxysulphion, disengaged at the latter point, had dissolved the copper of the zincode, which, however, had no power to pass to the platinode, to replace the metal, which had there been deposited.

"The preceding experiments bear closely upon an observation familiar to persons

Digitized by Google

engaged in electrotyping on the large scale, viz., that the solution around the platinode becomes impoverished, and at last nearly deprived of copper."

Thus metals capable of decomposing water at ordinary temperatures had been found susceptible of transference, and those which do not thus act, remain stationary. On inquiring for the class to which ammonium belongs, *muriate of ammonia, microcosmic salt,* double *tartrate of soda and ammonia* were severally electrolyzed, and "it was ascertained that ammonium is included in that class of basic compounds that refuse to travel in the voltaic circuit."

Comparative experiments on salts of potassium, barium, and magnesium, indicated a dependence of the transfer upon the attractive power of water on its elements.

"The supposed anomalous transfer of sulphuric acid, in the electrolysis of its mixture with water, the investigation of which cost so much labour upon a former occasion, is now easily accounted for upon the hypothesis of the unequal transfer of the oxysulphion and hydrogen of the hydrate to their respective electrodes."

Some connection was then traced between the attraction of different *acids* for water, and their transfer to the zincode, by the successive electrolysis of *tungstate of soda, chromate of potassa, arseniate of potassa, carbonate of soda,* and *chloride of sodium.* The simple electrolysis of binary compounds, as the *fused chloride,* could not be managed for want of a permeable diaphragm that would withstand the necessary heat.

The authors then give the following classification of electrolytes:—

"1st.—An electrolyte may consist of *simple ions,* and then must be constituted of a single equivalent of a metal (or H) for its cation, and a single equivalent of a non-metallic element for its anion; as K, I; Ag, Cl; &c.: they may be termed *simple electrolytes.*

"2nd.—An electrolyte may consist of a *compound cation,* a single equivalent of which must take the place of a metal; and a single equivalent of a *simple non-metallic anion,* as $N\ H_4$, Cl....these and the following we may call *complex electrolytes.*

"3rd.—An electrolyte may consist of a *compound anion,* a single equivalent of which would take the place of the simple non-metallic anion, with a single equivalent of a *simple cation,* a metal (or H), as $H, N\ C_2$; $K, S\ O_4$; $Na, N\ O_6$.

"4th.—An electrolyte may consist of a single equivalent of a *compound cation,* and a single equivalent of a *compound anion,* as $N\ H_4$, $S\ O_4$.

"These four cases may be included in the term *Monobasic Electrolytes,* as a single equivalent of force (measured by the voltameter) would electrolyze single equivalents of the electrolytes.

"5th.— An electrolyte may also consist of *two or more equivalents of a metallic cation* (or H) or of *single equivalents of two or more metallic cations* (or H); when the *anion* must consist of a *single equivalent of a compound ion,* as (K_2 Fe Cy_3). This compound ion, in the case of an oxysalt, contains the so-called anhydrous acid in combination with as many equivalents of oxygen as there are of metallic cations (or H) in the compounds, as ($Na_3\ P_2\ O_5\ O_3$).

"In this case, as many equivalents of force will be required for the electrolysis of one equivalent of the electrolyte as there are equivalents of metal (or H) in the cation. They may be denominated *Polybasic Electrolytes.*"

The authors conclude with a summary of facts, which they believe to be irreconcilable with any molecular hypothesis hitherto imagined.

Digitized by Google

"The disengagement of the cation and anion of an electrolyte in equivalent proportions is not always effected, as is commonly represented, by their simultaneous transfer in opposite directions to their respective electrodes, in the exact proportion of half an equivalent of each; but is sometimes brought about by the transfer of a whole equivalent of the anion to the zincode, whereby a whole equivalent of the cation is left uncombined at the platinode, or by transfer of unequivalent portions of each in opposite directions, making, however, together a whole equivalent of matter transferred to one electrode or the other; or, speaking more correctly, *by the transfer of a quantity of matter capable of exerting one equivalent of chemical force:* so that, when the anion *transferred* to the zincode exceeds half an equivalent, the cation transferred to the platinode is in an equal proportion less than half an equivalent, and *vice versâ*, the anion and the cation *set free* being always in equivalent proportions. We have, however, in no case observed the transfer of a whole equivalent of the cation to the exclusion of the anion."

BRITISH ASSOCIATION.

The Association met on the 26th of September, under very favourable auspices at York, the town at which their first meeting was held. The contributions to Electricity were few.

Mr. John Goodman read a paper "*On the Analogy of the Existences or Forces, Light, Heat, Voltaic and Ordinary Electricities.*" This communication was of a theoretical character, in which the author endeavoured to shew the connection between the phenomena of heat and those of electricity.

On a New Process of Magnetic Manipulation, and its Action on Cast Iron and Steel Bars. By the Rev. Dr. Scoresby.

Dr. Scoresby found that it was impossible, by the ordinary process, to communicate the full charge of magnetic influence, to very hard shear-steel or cast-steel bars, or such as were best suited for retaining it, and, therefore, best for the manufacture of compasses. But he was led by the theoretic views he holds, to try the effects of interposing thin bars of soft iron between the charging poles of the magnet, and the steel bar to be magnetized; this answered effectually, and Dr. Scoresby exhibited to the Section several experiments, whereby, with the old process, the magnetism imparted to the steel bars was very trivial, but by the adoption of the new process, a remarkably strong charge was communicated by one single stroke of the poles of the magnet over the bar.

On a Method of Electrotype, by which the deposition on minute objects is easily accomplished. By L. L. Boscawen Ibbetson, Esq., K.R.E., F.G.S., &c.

From the difficulties which arose from the application of plumbago in the ordinary manner, a portion of the plumbago was united with a solution of phosphorus in naphtha (coal oil), and the article to be electrotyped immersed in it. It thus became covered with a coating, on which the metal was deposited in a beautiful and uniform manner; some specimens of cacti thus covered with metal were exhibited. Setting aside the plumbago, this solvent of phosphorus is vastly superior, both in economy and safety, to the sulphuret of carbon used by many.

Prof. Grove communicated a notice by Mr. Gassiot, of a repetition of his experiment on the production of electricity without contact.* As Mr. Gassiot's paper appears in the *Electrical Magazine*, we need not do more than refer to it. Some allusion having been made to the curious phenomena observed by Moser and Mr. Hunt of the effects which bodies in juxtaposition produced on each other,

* Vide *Elec. Mag.* No. 6, p. 463.

Digitized by Google

Mr. Hunt remarked, that he was now inclined to refer all the phenomena to electrical excitation, rather than to any calorific disturbance, as he at first imagined.

The measure of Nervous Force developed by a current of Electricity. Prof. MATTEUCCI.

In another page (497) our readers will find M. Matteucci's experiments, in a translation of a paper read before the French Academy. Prof. Grove explained to the Association the substance of the memoir which had been read in French; he also suggested the substitution of the galvanometer for the voltameter.

LONDON INSTITUTION.

THE several Courses for the present Session are an indication of the zeal and activity of the Board of Managers. Mr. Grove, who occupies the Chair of Experimental Philosophy, opened the Session, with a Course *On the History and Philosophy of Electricity*, of which the following is the Syllabus:—

LECTURE I.—(Nov. 11th.)—Introduction—Early progress of the Science—Attraction—Repulsion—Gilbert—Guericke—Hawksbee—Coulomb.

LECTURE II.—(Nov. 18th.)—Franklinic Electricity—Different modes of excitement—Conduction—Grey—Nollett—Franklin.

LECTURE III.—(Nov. 25th.)—Franklinic Electricity continued—Induction—Leyden Phial—Von Kleest—Muschænbrook—Bevis—Watson.

LECTURE IV.—(Dec. 2nd.)—Various effects of Franklinic Electricity—Animal Electricity—Beccaria—Priestly—Galvani—Matteucci.

LECTURE V.—(Dec. 9th.)—Voltaic Electricity—Rationale and general laws of its action—Fabroni—Volta—Ritter—Davy—Faraday.

LECTURE VI.—(Dec. 16th.)—Voltaic Electricity continued—Different Voltaic combinations—Wollaston—De Luc—Pepys—Daniell—Smee.

LECTURE VII.—(Dec. 23rd.)—Voltaic Electricity continued—Electro-precipitation—Magneto and Thermo-Electricity—Oersted—Seebeck—Becquérel—Jacobi.

LECTURE VIII.—(Dec. 26th.)—Identity of Electricity from different sources—Methods of measuring its force—De la Rive—Wheatstone—Gassiot—Conclusion.

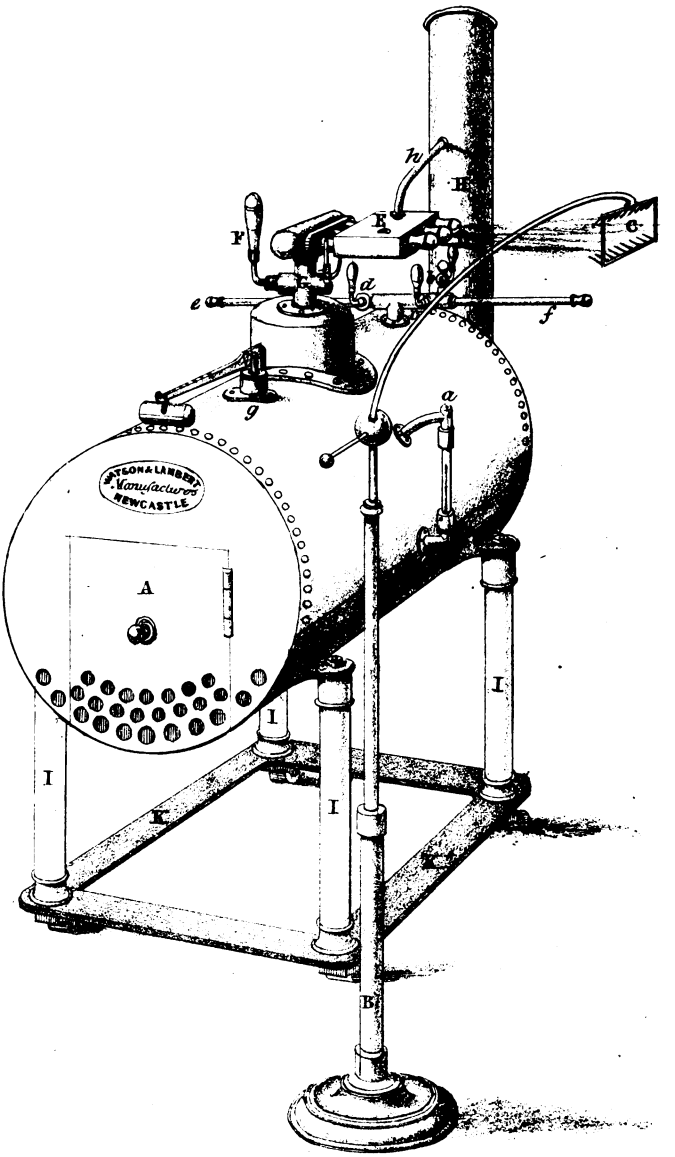
A popular course necessarily precludes the introduction of new researches; but these lectures are throughout interspersed with many bright thoughts, which do not fail of arresting the attention of the lover of physical science. Prof. Grove aptly compared the two electricities to the complementary colours;—he appears entirely adverse to the idea of fluid, and regards electric phenomena as polarizations;—he admired Faraday's philosophy of "matter," although he felt as much the difficulty of obtaining clear ideas of this, as of the atomic constitution;—he considered that the electric spark is always attended with a metallic or analogous emanation between conductors. Among the voltaic arrangements, he exhibited Martyn Roberts's combination;* and his own Gauze Battery.† The institution have provided themselves with one of Armstrong's Hydro-Electric Machines, made by Watson and Lambert, which has been used more than once in the present course: it

* Vide *Proceed. Elec. Soc.* p. 356. † Ib. p. 117.

Digitized by Google

Digitized by Google

ARMSTRONG'S HYDRO-ELECTRIC MACHINE
Nº 6.C



Digitized by Google

contains all the latest improvements. The following is a description of the annexed drawing of the machine:—

The boiler is 2 ft. 6 in. in length, and 1 ft. 2 in. in diameter.—A, the door of fire-place. B C, conductor for collecting electricity from the steam. B, glass stem. C, collecting-points. D, escape tubes and jets. E, condensing vessel, enclosing the iron pipes, by which the steam is conveyed to the jets; the lower part of the condensing vessel contains water, which nearly reaches the lower side of the steam-pipes; from the latter are suspended filaments of cotton, which dip into the water, and by capillary action raise just sufficient to cause, by its action on the pipes, a condensation of the passing steam into the requisite quantity of water for rubbing against the jet. F G, the cock for letting off the steam. H, the chimney. I I, insulating glass pillars. K K, frame moving on castors. *a a*, water-gauge. *f e*, condensing pipes for showing the effect of impregnating the ejected water with extraneous substances; and for exhibiting two jets of steam simultaneously issuing from the boiler in opposite states of electricity. *b*, cock for introducing extraneous matter. *c d*, cocks for admitting steam to the pipes. *g*, safety valve. *h*, escape pipe for the vapour of the condensing tube. The fuel is charcoal; and no annoyance is experienced in a tolerably spacious room. When in good working order, the machine produces as much electricity as three 30-inch plate-glass machines.

MR. GASSIOT'S ELECTRICAL SOIRÉE.

On Friday, Oct. 4th, in compliment to Prof. Matteucci, Mr. Gassiot held an Electrical Soirée at his house at Clapham, to which a very large party of the Professors and lovers of science were invited to meet the illustrious philosopher of Pisa. The suite of rooms were thrown open at 8 o'clock; the tables were covered with electrical apparatus, and the results of electricity; among which latter, we observed a very fine salver of solid silver, and a large copper electrotype. Mr. Gassiot several times during the evening satisfactorily repeated his experiment of tension before contact.* His series of 100 Grove's was excited; wires were carried out upon the lawn, where the charcoal light was exceedingly brilliant,—so much so that its reflection was seen at the distance of several miles, and the appearance was believed to be due to some atmospheric meteor.—Our readers may remember that, on the occasion of De la Rive's visit to this country, Mr. Gassiot held a similar Soirée;† and we are sure that their voices will re-echo with ours, as we thus publicly thank Mr. Gassiot for these his zealous endeavours to help onward the science of electricity.

* Vide *Elec. Mag.* No. 6, p. 463. † Ib. No. 2, p. 100.

Digitized by Google

REVIEWS AND NOTICES.

Experimental Researches on Electricity. By MICHAEL FARADAY, D.C.L. F.R.S., &c.—Reprinted from the Phil. Trans. 1838-43, with other Electrical Papers from the Quarterly Journal of Science and the Phil. Mag., Vol. II.—Taylors, Fleet-street, pp. 302. Five Plates and Woodcuts.

WE have been long looking forward to the appearance of the present volume; and our hopes are more than realized, when we see that it not merely contains the rest of the author's series of Experimental Researches, but also the whole of his miscellaneous contributions to Electrical Science. We have here before us in two octavo volumes, and at a moderate cost, authentic reprints of all that has been done in Electricity by one of its most devoted lovers. Right heartily do we thank the illustrious philosopher for this edition of his papers. None can so well appreciate the value of these volumes, as they who have constant occasion for referring to what may be termed the "Classics of the Philosopher;" for the information contained in these volumes, he must needs possess the Transactions of the Royal Society for twelve years; several volumes of the Quarterly Journal of Science, and many numbers of the Philosophical Magazine; and among these he would have to hunt for the particular matter in question. This second volume refreshes our memory on subjects in the history of Electrical Research, which the present panting and striving after "some new thing," bids fair almost to obliterate. It is true, as the author remarks in his preface, that some of those papers "partake of a controversial character;" but it is a controversy that redounds so much to his soundness as a philosopher, and to his amiability as a man, that we would not have a single paragraph expunged. These points are admirably illustrated in his reply to Dr. Hare. The American philosopher had written a hypercritical letter of objections to the theory of molecular induction. Many of these objections were based on a careless reading, or on a contracted view of the subject, and others upon misconception of the author's language. And how does Faraday reply? He takes all the blame upon himself: he says, "The resulting impression on my mind is, that I must have expressed my meaning imperfectly, and I have a hope that when more clearly stated, my words may gain your approbation;" and he then, in a moment, without any effort, flies out of himself personally, and enters heart and soul as a philosopher into the examination of the several propositions, that had been put forth; at the conclusion of the investigation he again appears as himself, a true philosopher feeling very acutely, that the more he knows, the more there remains unknown. He says, in respect to some unanswered paragraphs:

"These opinions I esteem as of the utmost importance; but that is a reason which makes me the rather desirous to decline entering upon their consideration, in-

Digitized by Google

asmuch as on many of their connected points I have formed no decided notion, but am constrained by ignorance and the contrast of facts to hold my judgment as yet in suspense. It is, indeed, to me an annoying matter to find how many subjects there are in electrical science, on which, if I were asked for an opinion, I should have to say, I cannot tell,—I do not know; but, on the other hand, it is encouraging to think that these are they which if pursued industriously, experimentally, and thoughtfully, will lead to new discoveries."

But we must pass from the philosopher to his labours. The first volume, as most of our readers are aware, contained the first fourteen series of Researches from 1831 to 1838; the commencing portion of the present volume contains the 15th to the 18th series inclusive. The 15th is a "Notice of the character and direction of the Electric force of the Gymnotus." The fish upon which these researches were made was the specimen that was exhibited for several years in the Adelaide Gallery, but which died, March 14, 1842. Leaving our readers to acquaint themselves with the results, we are induced to reprint his suggestions to future experimentalists, as thrown out in the concluding paragraphs; and the more so as there are now two lively and active Gymnotus at the same place.

"The kind of experiment I am bold enough to suggest is as follows:—If a gymnotus or torpedo has been fatigued by frequent exertion of the electric organs, would the sending of currents of similar force to those he emits, or of other degrees of force either continuously or intermittingly in the same direction as those he sends forth, restore him his powers and strength more rapidly than if he were left to his natural repose?

Would sending currents through in the contrary direction exhaust the animal rapidly? There is, I think, reason to believe the torpedo (and perhaps the gymnotus) is not much disturbed or excited by electric currents sent only through the electric organ; so that these experiments do not appear very difficult to make.

The disposition of the organs in the torpedo suggest still further experiments on the same principle. Thus when a current is sent in the natural direction, i. e., from below upwards through the organ on one side of the fish, will it excite the organ on the other side into action? or, if sent through in the contrary direction, will it produce the same or any effect on that organ? Will it do so if the nerves proceeding to the organ or organs be tied? And will it do so, after the animal has been so far exhausted by previous shocks as to be unable to throw the organ into action in any, or in a similar, degree of his own will?

Such are some of the experiments which the conformation and relation of the electric organs of these fishes suggest, as being rational in their performance, and promising in anticipation. Others may not think of them as I do; but I can only say for myself, that, were the means in my power, they are very first that I would make."

The sixteenth series is "On the Source of power in the Voltaic Pile," considered under the heads of "Exciting Electrolytes, &c., being conductors of thermo and feeble currents. Inactive circles containing an electrolytic fluid. Active circles excited by solution of sulphuret of potassium, &c."

The seventeenth series is "On the Source of power in the Voltaic Pile continued." Its subdivisions are "The exciting chemical force affected by temperature. The exciting chemical force affected by dilution. Differences in the order of the metallic elements of voltaic circles. Active voltaic circles and batteries without metallic contact. Considerations of the sufficiency of

Digitized by Google

chemical action. Thermo-electric evidence. Improbable nature of the assumed contact force."

The eighteenth series is "On the Electricity evolved by the friction of water and steam against other bodies." The readers of the *Electrical Magazine* have already* been made acquainted with the contents of this paper; but many will now be glad of the opportunity of obtaining a copy of the paper itself.

The Second part of the volume takes us back into the early days of Electro-magnetic motions; and discloses to us the inductive reasoning by which Faraday, then young in Electrical Science, was led to the discovery of Electro-magnetic Rotations. We there have an historical statement respecting Electro-magnetic Rotation, in which the condition of the subject, when Faraday entered on it, is fairly and plainly stated; and his undoubted and undivided right to priority of discovery is established. Then follow Nobili and Antinori's experiments on magneto-electric induction, which were set on foot in consequence of a brief notice which had reached them of Faraday's previous researches. This paper strongly reminds one of Columbus and the egg. Our illustrious countryman has added notes to this communication, in which he gently but very decidedly takes from them their borrowed plumes, and claims them as his own; and, he takes occasion too to point out several errors into which they had themselves fallen; and others, which they had inadvertently attributed to him. Into these, however, he enters more at length in a letter, coming next in order, which was addressed to M. Gay Lussac, and inserted in the "Annales de Chimie." A letter by M. Negro is given, containing several errors which it was incumbent on Faraday to correct, as they would have led to wrong impressions. Next are two letters from our author to Richard Phillips upon the Magneto-electric spark, &c. Then follow replies to Dr. Davy, in respect to electro-chemical action; after which are some papers on the magnetic relations of metals; and others on a supposed new sulphuret and oxide of antimony. The next paper is "On the History of the Condensation of the Gases, in reply to Dr. Davy, introduced by some remarks on that of Electro-magnetic Rotation;" it originated in some observations contained in Dr. Davy's Life of Sir Humphrey Davy. The portion of the letter devoted to the gases is not printed here, because it refers to other than electrical matters. We have then Schoenbein's peculiar condition of iron, with Faraday's experiments, and his ideas of the cause; also a letter from our philosopher on the same subject to Mr. Brayley, thanking him for certain references to previous researches, and expressing in few words his own contributions on this matter; as thus:—

"The facts relating to gold and carbon in association with iron; the experimental results as to the electric currents produced; the argument respecting the chemical source of electricity in the voltaic pile; and my opinion of the cause of the phenomena is due to a relation of the superficial particles of the iron to oxygen, are

* Vide No. 2, p. 129.

Digitized by Google

what remain in the character of contributions to our knowledge of this very beautiful and important case of voltaic condition presented to us by the metal, iron."

Dr. Hare's letter, and Faraday's reply, alluded to in the commencement of this notice, are the next papers; followed by a letter "On some Supposed Forms of Lightning;" which should be read and remembered by all, who make observations on lightning-flashes. The concluding papers are "On Static Electrical Inductive Action;" given in the *Electrical Magazine*, No. I. p. 66; and "A Speculation touching Electrical Conduction and the Nature of Matter," given in No. 4. p. 295.

Here we have then a goodly collection of contributions to Electrical Science; and from the pen of one, who has played so important a part in forming the science. The reader, who chooses to enter patiently on the study of these pages, will rise up having his mind richly stored with the most valuable facts; he will have traced the connecting links, by which apparently distinct facts have been associated; he will see the spots, where the chain breaks off: he will find a marked line drawn between the real and the probable; and, if his heart is in the matter, and he enters on it with ardent zeal, he will be able to look onward to those paths, which are as yet untrodden; and, if he ventures to explore them, he has with us our good wishes, that he may go on and on collecting the treasures of science at every step. But while he is making himself master of these Researches, let him endeavour to acquire, after the example of our esteemed philosopher, the somewhat difficult virtue of acknowledging human fallibility; let him learn to rub away that pride which is so common amongst us, among the younger of us especially, of thinking ourselves always right; of being unwilling to recall our earlier opinions. Forgetting, for a time, the philosopher, we have repeatedly had our thoughts directed to the man throughout these volumes, and cannot but admire the plain honesty and obvious sincerity with which he several times refers to previous statements, and confesses that he was wrong. In the hands of such a philosopher, science cannot but have gone on we l

---

On the Connexion of Geology with Terrestrial Magnetism, &c. By Evan Hopkins, C.E., F.G.S. Twenty-four Plates. Taylor's, Fleet-street, 1844.

The author of this volume is practically versed in mining operations; the facts he puts forth are the results, for the most part, of his own observation; the laws regulating the distribution of metalliferous deposits, and other magnetic phenomena, are, in the author's opinion, established by these facts. These laws are, to furnish some well-grounded principle to guide us in mining operations, and to do away with "guess work." There seems to us too many gratuitous propositions in the electric chapters; and if the geological deductions are based on these, they are somewhat unstable. We are no geologist, but have enough of logic left to deny the following inference:—"Were we to speculate on this subject,

Digitized by Google

we should consider it (the globe) filled with hydrogen gas, *from the fact of its surface being composed of water.*" If other geological deductions are drawn from such premises as these, we fear that much guess work remains. However, the publication is a motion in the right direction; and if we may not expect in it a complete theory of geological formation, the geologist may read it with profit, and find in it many valuable facts.

Traité des Phénomènes Electro-Physiologiques des Animaux. Par Ch. Matteucci; suivi *d'Etudes Anatomiques sur le Système Nerveux et sur l'Organe Electrique de la Torpille.* Par Paul Savi. Paris: Fortin Masson and Co., 1844., 8vo. pp. 348. Plates.

The author of the present volume, at least of the commencing and major portion of it, which it is now our desire to analyze, paid a visit to this country at the time of the late meeting of the British Association at York, in order to communicate to that body the results of some of his later researches in Electro-physiology, and to which we have elsewhere alluded. He brought with him his zeal and ardour in the branch of electricity, which he has made so peculiarly his own; and has done an essential service to our electro-physiologists, by the very admirable lessons he has given them in the manipulations necessary to insure success. It is one thing to read of experiments: but another and a widely different matter to see and to take part in them. And, but for the impulse his presence amongst us has given, his beautiful researches had well nigh been shorn of half their brilliancy through our bungling attempts at repetition. During his brief sojourn in London, he devoted a greater portion of several days in the Laboratory of King's College, to series of illustrative experiments on the leading phenomena of electro-physiology; and there, in the presence of Prof. Faraday, Wheatstone, Daniell, Miller, Drs. Marshall Hall, Todd, Bowman, Pereira, Billing, Mr. Gassiot, and other able physiologists and electricians, we had the opportunity of seeing these remarkable experiments, and becoming acquainted with all the precautions to be regarded in order to ensure successful results. The following extract from our note-book refers to an anterior experiment, which we witnessed in M. Matteucci's chamber at his hotel, and which is interesting, as describing the first production of the "muscular current," in London, and it will serve in anticipation of what we shall presently describe:—

Saturday, Sept. 20, 1844.—"He cut off the hinder limbs of three frogs, and then cut pieces off their legs, which he placed in series, the inner side of one muscle being in contact with the outer of the next: he laid them on a mahogany plank, the extreme ends of the series being in contact with pure water, in two cells or cups contained in the wood. Two platinum terminals were connected with an exceedingly delicate galvanometer; their action in either cell was first shown to be null; and then, when one was placed in each cell, the cells being connected by the series of muscles, six in number, the needle of the galvanometer deflected 30°; with four in

Digitized by Google

series, the deflection was from 15° to 20°. When three were placed in one order, and the other three in the reverse, making the same circuit, but so that the effect should be opposed, the needle remained at zero.—When connections were reversed, the deflection was also reversed. These experiments were several times repeated."

The volume before us contains the results of the professor's varied researches, divested of their original character of memoirs, and digested into a very interesting treatise on Electro-physiology. The first chapter is an historical introduction; it mentions the following singular experiment, made before the Grand Duke of Tuscany in 1678, and described by Swammerdam in a work entitled *Biblia Naturæ*, at p. 849 of the second volume:—

"Let there be a cylindrical glass tube, in the interior of which is placed a muscle, whence proceeds a nerve that has been enveloped in its course with a small silver wire, so as to give us the power of raising it without pressing it too much or wounding it. This first wire is made to pass through a ring bored in the extremity of a small copper support soldered to a sort of piston or partition; but the little silver wire is so arranged that on passing between the glass and the piston, the nerve may be drawn by the hand and so touch the copper. The muscle is immediately seen to contract."

This experiment was as much unknown to Galvani as to ourselves; and it is one among the many illustrations of the close approaches which may be made to natural truths without the actual attaining to them; it is a practical commenting upon Dr. Paris's observation in the life of Davy, "that truth may be often touched, but rarely caught in the dark." But is not the discovery of Electro-physiology itself one of these rarely-caught truths,—one of these hap-hazard discoveries lighted on in the dark? We have been taught to consider it as such; we hear Arago say, "It may be proved that this immortal discovery arose in the most immediate and direct manner from a slight cold with which a Bolognese lady was attacked in 1790, and for which her physician prescribed *frog-broth;*" and this is but one of the many changes that have been rung on the following note:—"When one of Galvani's pupils was using an electrical machine, a nnmber of frogs were lying skinned on an adjoining table for the purpose of cookery. The machine being in action, the young man happened to touch with a scalpel the nerve of the leg of one of the frogs, when to his great surprise, the leg was thrown into violent convulsions."* We have heard this note in all its variations so sounded in our ears at every corner, that we have been almost compelled to accept it in spite of ourselves; yes, in spite of ourselves; for, notwithstanding the unseemly whereabouts of the delicacy intended for the invalid Lucia,—and, notwithstanding the unpardonable want of bienséance in the young man in touching articles of food with the scalpel, in presence too of the sick lady, who was to partake of them, we have been fain to accept this version of the story for want of a better. But it appears from a manuscript of Galvani's, bearing the date of Nov. 6, 1780, in which these contractions are described, that "the frog was prepared in the *usual manner;*" and from two memoirs

* Vide Enc. Brit.: Art. *Voltaic Electricity.*

Digitized by Google

presented to the Institute of Bologna, one "On the muscular movement of frogs," dated April 22, 1773; and the other "On the action of opium on the nerves of frogs," dated Jan. 20, 1774, six and seven years antecedent, it is very evident that frog experiments were no new thing to him; and that he had long been accustomed to preparing frogs. And this offers a satisfactory explanation of the presence of the frogs in the laboratory; they were evidently there for the purposes of experiment; and "were not found by chance on his table beside the electric machine." The works of Galvani, which have lately been published at Bologna, as noticed in our list of *New Books*, may possibly throw some interesting light on this question; be this, however, as it may, we must thank the philosopher of Pisa, for enabling us to do justice to the merits of his countryman.

Galvani was more deeply versed in the theory of electric influence than is generally thought, as is apparent from a Latin memoir of his, which is but little known; in his treatise on the conducting arc, he states that the contraction might be explained by the return shock. It is interesting to find his own endorsement on a page, dated Sept. 20, 1786, describing the first experiment with the metallic arc:—his words are "*Experiment on the electricity of metals.*" He also touched upon the influence of electricity on the nerve alone; but it did not excite his attention; for he was in the habit of regarding the nerve as a mere conductor for effecting a discharge of the proper electricity of the muscle, the *animal electricity;* though at the same time he says "*many of the contractions*, obtained with the metallic arc, are due to the arc itself." We must not, however, take from our author the privilege of telling his own tale; and, therefore, refer our readers to the rest of this chapter in which they will find the chief features of the early history of galvanism; and, ceasing for a time to be dazzled, as we have all been, with Volta's brilliant discovery of the pile, they will be able to look calmly and, we trust honestly, at the claims of his illustrious precursor.

We have mentioned that Matteucci's experiments have failed on repetition through careless manipulation; and have therefore translated his second and third chapters (which are on the use of the instruments required), into another portion of the "*Electrical Magazine;*"* in this, we are conscious of fulfilling the wishes of the author.

The fourth is a short chapter of researches on the relative conducting powers of nerve and muscle; the order of manipulation was to pass a current along either of these substances, and then to take out of each a *derived* current (*vide* p. 488) and pass it through a galvanometer: this is readily done by fixing the galvanometer terminals through two corks sliding on a glass tube, so that any given distance between them may be readily obtained and maintained. From the experiments, it appears that "the conduc-

* P. 475, 482.

Digitized by Google

tibility of muscle is four times greater than that of nervous and cerebral substances; which latter do not sensibly differ in conductibility;" if there is a difference, it is in favour of nerve. In the course of these investigations, it was shown that "this derived current is sometimes double, and always stronger, when the current of the pile passes from the spinal marrow to the crural nerve, than when it pursues a contrary course." The author does not lay much stress on this chapter; as the matters on which it treats, require following out.

The fifth chapter is on the "*Muscular Electric Current*," an electric development, co-incident with the chemical action, attendant on the growth of the muscle, as the ordinary voltaic current is with the action of the elements in the cells. The direction of this current, in the muscle itself, is from the inside to the outside; it can be detected in a single pair, so to speak, that is, in one piece of muscle, and can be greatly exalted by placing pieces of muscle in series, as in the experiment we just now described (p. 542). We have ourselves seen it developed from a wound in a pigeon's breast, when the nerve of the "galvanoscopic frog" (p. 480) was made to touch the inner and the outer side of the wound; we have seen it repeatedly from piles of the muscle of frogs, and also from piles of the muscle of pigeons, and of eels. These effects vary in intensity according to the rank the animal operated upon occupies in creation; and they cease, sooner or later after the death of the animal; it seems also that animals, highest in the scale of creation, have a muscular current of greater intensity, while life lasts; but they lose it much faster after death, than do those lower in the scale. From a long series of experiments on circumstances, which might influence the activity of this current, the following conclusions are drawn:—

The intensity of the muscular electric current varies in cold-blooded animals, in proportion to the temperature of the medium, in which they have lived for a certain time: the direction of this current after death is less as the animal is higher in the scale of beings: the intensity of the muscular current varies with the degree of nutrition of the muscle, and it is always more powerful in muscles that are gorged with blood and inflamed: this current is altogether independent of the integrity of the motive and sensual system, and of the activity of this system: the influence of narcotic poisons on this current is nothing or very feeble: among the different gaseous poisons, sulphurretted hydrogen alone acts in a remarkable manner in weakening the intensity of the muscular current: the direction of the muscular current is constant in all cases."

The *current proper* of the frog, which is next before us, is entirely distinct from the *muscular current*; it is exhibited when the paw of the prepared frog is made to touch the exposed cruval nerve, by the contraction which ensues; it is also shewn by placing the lumbar nerve of a prepared frog in one vessel of water, and the legs in another vessel; and completing the circuit with a galvanometer: or its intensity may be increased by making a kind of *couronne de tasses*, with prepared frogs thus arranged: in this latter case, the proper current itself throws the members, which

Digitized by Google

produce it, into active convulsions. The direction of this current is from the extremities upwards; it soon ceases after life is extinct, rarely lasting beyond a quarter of an hour; it may, however, be in a measure renewed by disclosing a fresh portion of the nerve. As this current travels from the extremities upward, it is not evidenced when symmetrical parts are in contact.

"The following is an easy means of proving this principle:—skin a very lively frog, and, as usual, cut off the spine with the bones and muscles of the pelvis; moreover, cut off also the iliacal bone, by which the two thighs are connected, and thus separate the frog into two halves, which remain joined by the two spinal nerves organically connected, in the piece of the spinal marrow. By arranging this frog on the insulating plane, and keeping the two thighs well separated and the nerves extended, it is very easy to observe that, on touching one thigh with the other leg, contractions always take place; while they are wanting when the legs are touched together. They may also be obtained, by touching different parts of the same legs with an arc of cotton or paper saturated with salt water. Still more powerful contractions are obtained in one of the legs by bending the nerves of the other so that the piece of spinal marrow touches the muscles of the thigh." p. 90.

"..... In a frog that is not lively, or in one employed some minutes after it has been prepared, only the member, of which the muscles of the thigh are touched, contracts on closing the circuit, whilst the other member remains tranquil. On opening the circuit, the contrary takes place, namely, the contraction happens only in the member of that limb, which was in contact with the muscles of the other thigh." p. 92.

Each limb of the frog appears from the experiments to be a complete electro-motive element; so that the want of contraction, when symmetrical parts touch, is because two currents of equal intensity circulate in opposite directions. No increase of deflection seems to be derived from two or three limbs placed side by side; M. Matteucci thinks that each limb conducts part of the proper current of the other; but it may be, we think, that the variations in quality are such that the galvanometer does not detect them. He made a certain series of dissections, which led to the following results:—

"1st. The proper current of the frog maintains its direction and intensity without the spinal marrow, and without the spinal and crural nerves, and although it was deprived of all the visible nervous filaments of the muscular mass of the thigh: 2nd. The electro-motive element of this current is reduced to the muscles of the leg and thigh united organically; 3d. When we leave to the frog prepared in the ordinary manner, its nerves and ramifications in the muscles, these nervous parts act in the production of the current, as the muscular substance of the thigh itself acts." p. 100.

Several experiments were made on prepared frogs that had been in contact with gases; on others whose limbs had been gorged with blood; and on some that had been exposed to cold: for the results, and their incidental phenomena, the reader is referred to the work itself.

The part played by the nerves in the muscular and in the proper currents appears to be simply that of conductors of the electricity developed in the part of the muscle near them; for, on making piles for the production of each order of phenomena, in which the nerves formed the connecting links between the respective legs or muscles, the same class of effects were produced, differing only

Digitized by Google

in intensity, which was less, on account of the resistance opposed by the comparatively badly conducting power of the nerve. Cases occur, in which the observed result may be a differential phenomenon, arising from the proper current moving in one direction, and the muscular current in the reverse; and again there are other cases in which the sum of the two effects may be obtained.

The constancy of the direction of the muscular current, and its entire independence on the integrity of the nervous system, added to its gradual reduction, as the activity of the functions of life cease, naturally lead to the inference that it is closely connected with the phenomena of nutrition; and when it is considered that these phenomena, inasmuch as muscular fibre is concerned, consist of the production of heat and the development of carbonic acid,—chemical action entirely analagous to that of the voltaic pair; when too, it is remembered, that this action is co-existent with life itself, the inference meets with strong confirmation.

"The metallic plate attacked is, in the phenomenon of the muscular current, represented by the fibre itself of the muscle: the arterial blood is the acidulated liquid. The surface of the muscle, or every other conducting body, which is not muscular fibre, but which is in contact with it, represents the second metallic plate, that suffers no chemical action, and which simply serves to form the circuit. The direction of the muscular current is precisely that, which it would have, in supposing it due to a chemical action, such as we have represented it, taking place in the muscle." p. 125.

The cause or origin of the proper current appears buried in mystery; and the mystery is the greater from the fact that no similar current has been found in any other animal; not even in salamanders, snakes, or tortoises; the *frog*, in this respect, *stands alone*.

A singular physiological phenomena presents itself, when the nerve of a prepared frog is made to rest on a muscle during its contraction; the frog itself contracts: this effect is screened off by the interposition of gold leaf, or an insulating body, but not when moist paper intervenes. It is not thought to be due to a derived current, nor is it attributed to mechanical action; but is supposed to arise from an electric discharge, produced by the contraction itself. The difficulty of putting this to the test of experiment may be imagined; means have not yet been devised, so that the question is unanswered; to use M. Becquérel's words, quoted by Matteucci:—

"Should experiments, undertaken in another direction, some day confirm the results drawn by M. Matteucci from this fact, that philosopher will have discovered one of the most important properties of muscles, while under the empire of life, and even some time after death." p. 134.

We should mention that it is not due to the proper current, because it is obtained by means of the muscles of other animals than the frog.

The author now turns to the history and philosophy of electric fish, but especially to the torpedo; he gives a brief notice of the principal discoveries, with the names of their authors; and, having

Digitized by Google

mentioned the instruments that are used, he describes the general phenomena of the electric discharges, including several particulars, that are less generally known :—

"A fact that merits being related is that of the extraordinary diffusion in a liquid; which is proved by the electric discharge of the torpedo. Very near to the sides of a large tub 1,^{m}5 (5 ft.) across, and full of salt water, I hold with my hand a living torpedo. At the opposite extremity is suspended in the water, almost at the same level, a prepared frog. Every time the torpedo discharges, the frog contracts violently. A pile of very great force would not produce this effect; especially if we observe that a great portion of the current circulates by the hand, and that another large portion must circulate by the surface itself of the animal." p. 46.

We have experienced this when the gymnotus give shocks; Faraday has also studied it in his fifteenth series. Our author adds :

"Movements, which are sometimes scarcely sensible are perceived in the body of the torpedo, when it gives the electric discharge; and sometimes these movements are very great. I convinced myself, by a very simple experiment, that it can discharge without any actual change occurring in its body. I introduced a female torpedo of moderate size, 0,^{m}14 (5½in.), into a jar filled with salt water, and with it a prepared frog placed on its body. The jar was accurately closed, and carried a glass tube of very small diameter. After having well luted the mouth, I filled the jar with water, so that the liquid rose in the little tube. The torpedo, from time to time, gave electric discharges, by a peculiar process that I shall presently describe; the frog too contracted; but the level of the liquid in the little tube was motionless." p. 146—7.

As it was important to determine whether any portion of the current, in the act of discharge, is transmitted along the nerves that lead to the electric organ, the greatest pains were taken to expose and insulate the four nerves which are thus directed; but, although the fish gave very violent discharges, not the slightest indication of a derived current could be obtained from any of these nerves.

In the following chapter, the causes which influence the electric discharge are investigated; the mass and temperature of the water are considered among the external causes, as is also the irritation to which the animal is exposed; a series of experiments are given "which confirm the principle already established, that the activity of the electric function is proportional to the activity of the circulation and respiration of the animal." Among the internal influential causes, the electric organ itself first claims attention; when this organ is destroyed, the integrity of other parts being retained, the electric phenomena cease; the only successful means of destroying this organ, or rather of depriving it of its function, is the contact of concentrated mineral acids, or of boiling water. Of the nerves leading to the electric organ, "it is not sufficient to cut one, two or three of these nerves in order entirely to destroy the discharge, but it is necessary to cut the whole four." When one or more nerves are cut, the discharge is confined to the parts of the organ, among which the intact nerves ramify. The discharge may also be prevented by tying the nerves. Even after the nerves are severed, the functions may be manifested by irritating the cut

Digitized by Google

nerve, unless the nervous trunks have previously been acted on by caustic potash. Of the four lobes of the brain, the fourth only, hence called the *electric lobe*, is found to actuate the electric organ, which it will readily do, when exposed and irritated; the upper portion of this lobe may be removed without the destruction of the electric functions; but when the whole lobe is taken away, the rest of the brain possesses no power over the discharge. The action of electric currents on the organ are next investigated; and the author finds,

"1st. That in a first period after death, in which the vitality of the nerves is still very great, the electric current, either direct or inverse, always produces the discharge, either at its commencement, or at the moment of rupture. 2nd. In the following period of vitality, the discharge is only produced by the commencement of the direct, and the interruption of the inverse current." p. 179.

The author then sums up the results of his researches on the torpedo, of which we have detailed the leading features, and gives the following as the conclusions to which they lead:—

"1st. The electric discharge of the torpedo and the direction of this discharge, depend on the will of the animal, which for this function has its seat in the electric lobe of the brain.

"2nd. The electricity is developed by the organ of the torpedo, commonly called *electric organ*, under the influence of the will.

"3rd. Every external action, which is directed on the body of the living torpedo and determines the discharge, is transmitted by the nerves of the irritated point to the electric lobe of the brain.

"4th. Every irritation directed on the fourth lobe or its nerves, produces no other phenomena than the electric discharge. This lobe and its nerves may, therefore, be called *electric lobes and nerves*; as we say, *nerves of sensation, motion nerves, nerves of organic life.*

"5th. The electric current which acts on the lobe or its electric nerves, produces nothing besides the discharge of the organ; and this action of the current remains longer than that of all other stimulants.

"6th. All circumstances, that modify the functions of the electric organ, act in an equal degree on the function of muscle, namely on contraction." p. 180.

This latter conclusion is happily illustrated by a table drawn out by M. de Blainville.

The next chapter is devoted to the gymnotus, and contains Humboldt's account of the mode of catching them, and Faraday's Researches on the specimen which had been so long in the Adelaide Gallery. From this chapter we give the following extract:—

"We have seen that there is in the brain of the torpedo a lobe especially destined to determine this discharge: we are as yet ignorant as to whether there exists in the brain of the gymnotus an analogous spinal lobe."

Our author, by referring to the papers by Dr. Lekeby in the Proceedings of the Electrical Society, will find that the analogous lobe exists; it is described as the medulla oblongata.

And here we must terminate our analysis for the present. The subsequent chapters by M. Matteucci are devoted to an examination of the influence of the electric current on living or on recently killed animals; and the therapeutic applications of electricity.

Digitized by Google

The volume terminates with anatomical studies of the torpedo by M. Paul Savi, illustrated by admirable plates.

Since the above observations were written, the Anniversary Meeting of the Royal Society has been held; and it gives us very great pleasure to report that the gold Copley medal has been awarded to Prof. Matteucci for his researches in Animal Electricity.

NEW BOOKS.

Experimental Researches in Electricity, by M. Faraday, Vol. II. 8*vo.* 9*s. cl.—Silvestri Gherardi de Electricitate et Magnetismo animadversiones variæ. Benoniæ,* 1840, 4*to. stitched.—Dell'Elettrotipia: Zantedeschi, Venice,* 1841.—*The Alphabet of Electricity: W. Higgins, Esq.,* 2*s.* 6*d.—Die Galvanisches Vergoldung, Versilberung, Verkupferung, &c.: Von Alexander Vetzholdt. Dresden and Leipsic,* 1842, 8*vo. pp.* 52, *plate.—Frankenstein's Einfache Hydro-electrische Contact, Vergoldung und Versilberung. Gratz,* 1842, 8*vo. pp.* 44, *woodcuts.—Praktische Anleitung zur Galvantschen, Vergoldung und Versilberung, &c., von Röszler. Frankfort-on-the-Maine,* 1842, 12*mo. pp.* 24, *plate.—Opere edité ed inedité del Prof. Luigi Galvani, raccolte e pubblicate per cura dell' Accademia delle Scienze dell'Instituto di Bologna. Bologna,* 1841, 4*to. pp.* 628;—*Aggiunta alla Collezione delle Opere del Prof. Luigi Galvani, pubblicata per cura dell' Accademia, &c. Bologna,* 1842, 4*to. pp.* 58.—*Articolo Analitico sull'Aggiunta alla collezione, &c.—Documento importante Afferto all'Annotatore della Collezione, &c. &c., by Prof. Grimelli. Modena,* 1842, 8*vo. pp.* 56.—*Galvanoplastie, ou Elemens d'Electro Métallurgie, &c. De Valincourt, Paris,* 1842, 18*mo., plate, pp.* 454.—*Traité de Galvanoplastie: J. L——. Paris,* 1843, *large* 8*vo., woodcuts,* 3 *francs.—Esperienze sui rapporti fra l'Induzione Elettro-Magnetica, &c. Prof. Botto. Memoirs of the Turin Academy,* 4*to. pp.* 44.—*Exercizio logico sugli errori d'ideologia e Zoologia; ossia l'arte de trarre profitto dai caltivi libri. Gioia. Milan,* 1824.—*Resultate der Magnetischen Beobachtungen in München,* 1840-2. *J. Lamont. München,* 1843, 4*to.—Annalen für Meteorologie und Erdmagnetismus. Nos.* 5 *to* 8, *München,* 1843, 8*vo.—Magnetische und Meteorologische Beobachtungen zu Prag.* 1843, 4*to.—Recherches sur la Puissance Motrice et l'Intensité des courants de l'Electricité Dynamique. M. de Haldat. Nancy,* 8*vo.—Principes d'Electricité, en Confirmation de la Theorie Electrique de Franklin: F. Gérard. Brussels,* 8*vo.—Notice sur le Zincage Voltaic du Fer et autres Mètaux. M. Louyet.* 1843, 8*vo.—Annuaire Magnétique et Météorologique du corps des ingénieurs des Mines de Russie. M. A. J. Kupffer. Année,* 1841, *Nos.* 1 *and* 2. *St. Petersburg,* 1843, 2 *vols.* 4*to.—Zweiten Zuzatz zu der Schrift; ueber der Galvanismus als Chemisches Heilmittel. Dr. Gustav*

Digitized by Google

Crusell. St. Petersburg, 1843, 8*vo.*—*Vital Air, Electricity, &c. Riadore.* 12*mo.*, 5*s.* 6*d.*, *cloth.*—*Sull'Elettro-Motore Perpetuo, instruzione teorico-pratica del Prof. Giuseppe Zamboni. Verona*, 1843, 8*vo. pp.* 96, *plates.*—*Trattato Elementaire di Elettricità accomodato all'intelligenza commune. Prof. Bordé. Modena*, 1843, 8*vo.*, *pp.* 174, *plate.*—*Resultat des Observations Magnétiques faites à Genève dans les Années*, 1842 *et* 1843: *M. Planta. Moan., Genèva*, 1844, 4*to.*—*Elements de Physique Expérimentale et de Météorologie: M. Pouillet. Paris, Nov.* 1844, 2 *vols.* 8*vo.*, *plates, pp.* 832 *and* 766.—*Natural Philosophy. Second Edition. Dr. Golding Bird.* 1844, 8*vo.*, *woodcuts, pp.* 480, *price* 12*s.* 6*d.* —*Archives de l'Electricité. De la Rive. Vol. IV., No.* 15, *Oct.* 24, 1844. *Geneva.*

NOTICES OF EXPERIMENTS, &c.

Double Flash of Lightning, &c.—"About seven o'clock, I saw two parallel trails of light rise from the ground and extend to the cloud; seen at a distance of about 3 k. m. (1·86 miles.) These two trails did not appear more than 4 metres (13·1 feet) apart. This is the first time I have seen two electrical pencils of light so powerful and so near together. In the storm which has just traversed Paris (Sept. 9) there was nothing remarkable except a continuous rolling of thunder, which lasted twenty minutes without interruption. An elevated electronometer indicated the numerous series of partial discharges, by which the continuous rolling was produced."—Peltier. Vide "*Comptes Rendus*," Sept. 9, 1844.

Continuous Thunder.—M. Chariet writes, that, on the 9th of September, the same day when a continuous rolling of thunder was heard at Paris (*vide* preceding extract), he observed a rolling of a precisely similar character at Corbigny, department of the Nièvre. —*Comptes Rendus*, Oct. 7, 1844.

Facts (?) for the History of Electricity.—We think it right to record that, in this present year, 1844, fragments of native loadstone are eagerly purchased, and are carried about the person as amulets against rheumatism. They are believed to be efficacious. We also print, among the curiosities of electricity, the following extracts from hand-bills. The rings alluded to continue to be sold. They are of zinc externally, having a copper ring let into the inner side:—"Galvanic Finger Rings, for the medical application of galvanic influence, to alleviate the excruciating and agonizing pains of tic doloureux and nervous toothach, painful rheumatic affections, spasms, cramps, pains, &c. &c.—All that is necessary is to include any finger in the galvanic ring so as to fit close, but not tight;—should a tingling or uneasy sensation extend along the arm, the ring must then be taken off, and may be put on at the

Digitized by Google

expiration of a few hours if at all necessary. Dr. Graham highly recommends galvanism in palsy, rheumatism, deafness, &c. In the galvanic rings, the electric principle appears to be excited by the acid secretions from the finger, and thus acts upon the nervous system to allay irritability."

The following is from the other card:—"*The Galvanic, Electric, and Magnetic Ring* alleviates the excruciating and agonizing pains of *tic doloureux* and painful rheumatic affections. It is perfectly harmless, and may be applied in all cases with the greatest safety. Its efficacy is undisputed, never being known to fail in accomplishing the desired purpose. It has received the approbation of the medical profession, who have pronounced it to be the most important of modern scientific inventions. The charge is so low as to be within the reach of all classes, even of the humblest mechanic. The great influence it exerts on the nervous system is truly astonishing; it must be witnessed to be believed."—[After this, Matteucci must be silent for ever; for what be his *direct* and *inverse* currents (*vide* p. 490) to this? We must confess, however, that until now we had been taught to believe that the finger-ring which exerted the greatest influence over the nervous system was one of plain gold, placed on the fourth finger of the left hand. This ring, we had thought, excited both the hand which gave and that which received it. By-the-by, we have encircled our finger with the said ring (not the gold one), but whether our faith is weak, or we have no *tic doloureux* to operate upon, the charm is lost upon us.—*Ed.*]

Prize proposed in Electricity.—The Brussels gold medal, value 600 francs, will be awarded to the author of the best memoir on the following subject:—"*To examine and discuss the theories that have been proposed up to the present time, in order to explain the origin of voltaic electricity, and the mode of action of piles.*" The memoir to be legibly written in Latin, French, or Flemish, and sent to M. Quetelet, the secretary of the Brussels Academy, before February 1, 1845.—*Bull. R. Academy, Brussels*, 7th and 8th May, 1844.

Thunder.—"I was here (*Campo Doleino*, Aug. 24, 1844) interrupted by one of the most awful peals of thunder I ever heard; one of the effects of which was to bring the wind suddenly round to the north, accompanied by a fall of snow, and which shortly afterwards was succeeded by such a fine blue sky, that I determined, at all risks, to get on to Chiavenno."—*Correspondent to Athenæum* (Sept. 14, 1844).

Improvement in the Hydro-Electric Machine.—We had the opportunity of being present at the trial of a machine made by Watson and Lambert, for Herr Döbler, the well known professor of natural magic. The condensing tube passed through an enclosed iron vessel containing water; cotton threads, hanging from the tubes, dipped into the water (after the manner of the wet-bulb thermometer arrangement); and the cold of evaporation produced

Digitized by Google

the required condensation. Additional tubes and jets were provided for the introduction of chemicals, that cause the character of the electricity to vary.*—*Ed.*

Frequency.—This word of Beccaria's has lately been revived into electro-meteorology. It is used in reference to the greater or less amount of time required by the insulated collecting apparatus to acquire a charge.—Ed.

Clauses in the Railway Act respecting Electrical Telegraphs.—"13. And whereas electrical telegraphs have been established on certain railways, and may be more extensively established hereafter, and it is expedient to provide for their due regulation; be it enacted, That every railway company, on being required so to do by the Lords of the said Committee, shall be bound to allow any person or persons authorised by the Lords of the said Committee with servants and workmen, at all reasonable times to enter into or upon their lands, and to establish and lay down upon such lands adjoining the line of such railway, a line of electrical telegraph for her Majesty's service, and to give to him and them every reasonable facility for laying down the same, and for using the same for the purpose of receiving and sending messages on her Majesty's service, subject to such reasonable remuneration to the Company, as may be agreed upon between the Company and the Lords of the said Committee, or in case of disagreement as may be settled by arbitration: Provided always, That, subject to a prior right of use thereof for the purposes of her Majesty, such telegraph may be used by the Company for the purposes of the railway, upon such terms as may be agreed upon between the parties, or in the event of difference, as may be settled by arbitration.

"14. And be it enacted, That where a line of electrical telegraph shall have been established upon any railway by the Company to whom such railway belongs, or by any company, partnership, person or persons, otherwise than exclusively for her Majesty's service, or exclusively for the purposes of the railway, or jointly for both, the use of such electrical telegraph, for the purpose of receiving and sending messages, shall, subject to the prior right of use thereof for the service of her Majesty, and for the purposes of the Company, and subject also to such equal charges and to such reasonable regulations as may be from time to time made by the said Railway Company, be open for the sending and receiving of messages by all persons alike, without favour or preference." *Anno Septimo et Octavo*, Victoriæ Reginæ. *Cap.* LXXXV. Passed Aug. 9, 1844.

The August Meteors.—Besides an unusually splendid display of these visitants on the nights of the 9th and 10th of August, 1844, a vast number of fine white lines were observed by Dr. Forster at Bruges; they resembled narrow discharges of the Electrical spark, appeared aloft, and had the same direction toward Scorpio, all tending to the W.S.W. position.—*Times.*

* *Vide* a plate of a similar machine in present number.

Digitized by Google

Daguerréotype Prints.—"I have lately received from Rome fine specimens of Rondoni's daguerréotypes, of various nebulæ, *printed directly from the stone* on which he takes the impression. They are really very good; and I hope ere long to have the pleasure of showing them to you."—*Mr. Lettsom to Mr. Weekes*, Aug. 13, 1844. [We believe we are correct in stating, that M. Von Kobel has succeeded most effectually in engraving and printing from daguerréo-plates.—*Ed. Elec. Mag.*]

Colouring Daguerréotypes.—Professor Page deposits on the picture a thin film of copper, by the electrolysis of the cuprocyanide; washes with distilled water, and then heats over a spirit-lamp, until the light parts assume a pearly appearance. By varying the thickness of the deposit, and the degree of heat applied, different colours come out.—*Franklin Journal*, May, 1844.

Electrolysis of Double Cyanides.—Our readers are referred to the *Philosophical Magazine*, for November, for some details by Mr. Napier, which go towards showing the use of free cyanide in these solutions; and the manner in which cyanogen is transmitted along the electrolyte.—*Ed. Elec. Mag.*

Daring Experiment by Galvani.—"We cannot read, without shuddering, of an experiment described in his papers, which was made April 7, 1786. Galvani held in his hands the rod of an insulated atmospheric conductor, at the very moment when lightning was bursting in the skies."—*Matteucci's Electro-Physiology*, p. 7. He was at the time trying the effect of atmospheric electricity on frogs.—*Ed.*

OMNIA.—A correspondent recommends varnished cups of ripened acorns for mercury cups.—A popular notice of Messrs. Elkington's electro-plate factory is given in the Supplement to the *Penny Magazine*, No. 807.—The "electro-chemical copying book" is a name with which we have lately met. It is a kind of manifold writer.—M. A. Morren promises a paper on electric pictures.—M. Garnier has remarked, that the electric current has no action on the magnetic needle while it is engaged in decomposing water. This, surely, is not a general proposition!—The museum at King's College contains a *rheo-electric* machine, once the property of George the Third. It consists of a cylinder of glass and one of resin.—In a large manufactory in Belgium, and we believe elsewhere, a powerful magnet is placed at hand for extracting particles of iron which may chance to enter the eyes of the operatives. Magnets have been employed to remove particles of iron from the pulp of paper.—M. de Ruolz had deposited bronze from a solution of cyanide of copper and oxide of tin.—M. Jacobi now deposits brass from a cyanide solution of copper and zinc with a brass anode.—Prof. Schöenbien has published a long memoir on Ozone. It occupies 120 pages of the last number of the *Archives*.—A publican has been taken before the civil authorities at Liverpool, for inducing young men to place themselves in a weighing machine, and when there he administered to them very severe electro-magnetic shocks.

Digitized by Google

ELECTRICAL MAGAZINE.

APRIL, 1845.

LXXXVIII. *On Electro-Magnetic and other Vibrations.* By WM. BEATSON, Esq.

TO THE EDITOR OF "THE ELECTRICAL MAGAZINE."

DEAR SIR,—In the *Literary Gazette* for November last, I have seen an account of the discovery, by Mr. Marrian, of sounds emitted by an electro-magnet at the period of making and breaking contact with the voltaic battery. It is now upwards of two years since I discovered the same fact, and showed the experiment to various individuals. Since that time I have tried a number of experiments on bars of different sizes and materials, and I would not now trouble you with this communication, but that I thought a few additional facts might prove of some interest in explaining these curious phenomena.

I was led to notice the sound proceeding from an iron bar, when surrounded by the voltaic wire, by applying my ear to the end of a large electro-magnet of the horse-shoe form, at the time when the voltaic circuit was completed, and by observing a kind of knock or pulsation both when connection was made with the battery and also when it was broken. On removing the coils and suspending the same iron bar so as to vibrate freely, and then circulating a voltaic current by a wire so as not to touch the iron bar, I obtained the distinct sounds already noticed. This was first effected with a single arrangement of Smee's battery in a pint cell; but with a more powerful battery and a longer bar of iron of course

Digitized by Google

much louder vibrations were obtained; and by breaking contact rapidly a few times in succession, I have elicited sounds as loud and distinct as those from a small bell. The electro-magnet which I first used was 5 feet long and 3 inches in diameter; but it is not at all necessary to use bars of such a large size, as I have obtained distinct sounds from an iron wire 6 inches long and $\frac{1}{8}$th of an inch in diameter. For the electro-magnetic telegraph this phenomenon will, I believe, be of considerable utility, as a sound sufficiently audible for many purposes may be procured with a comparatively feeble electric current, when rapidly interrupted a few times in succession. I do not think that it is material whether the iron bar is straight or bent in the form of the horse-shoe, but for convenience and utility I generally prefer the latter shape. Thinking that probably a ring of iron would give a different result, I passed a voltaic current through a coil surrounding the iron, but found that it emitted the usual sounds, both when the current was made to circulate round the iron for half, as well as the whole, of the circumference.

On trying the experiment with steel bars, I observed that a cast steel bar, 2 feet long and 1 inch in diameter, when made quite hard, and placed in the coil, emitted no sound that I could detect, even when using a considerable voltaic power; probably with a larger bar a sound may be elicited; but even then it would most likely arise from defective hardening, caused by the increased bulk of material. When the same bar was reduced in hardness by tempering it to a straw colour, I could then distinguish clear but feeble sounds, when subjected to the influence of the coil; but in this instance I thought that the sound on making contact with the battery was louder than that produced when the circuit was interrupted, which is the reverse of what usually takes place.

When the bar was made quite soft by heating it red-hot and gradually cooling it, but without altering its steely properties, I obtained sounds nearly as loud as from soft iron under similar circumstances. The experiments with hard steel and steel somewhat softened I should wish to repeat with a longer bar and increased voltaic power, when probably more decided results might be obtained.

When a bar of cast iron, 6 feet long and 3 inches thick, was exposed to the influence of the voltaic coil, I noticed the usual vibrations; but the tone was very feeble; whilst with other bars of smaller dimensions I have procured sounds much louder and more distinct. The cause of this difference I have not had the opportunity fully to determine, though probably, as in the case of steel, it arises from different

Digitized by Google

degrees of hardness, produced either by the varying quality of the metal, or by a more or less rapid degree of cooling at the time when the bars were cast.

I have not been able to manifest these magnetic vibrations by induction of a steel magnet on a bar of soft iron, though I have little doubt but that the experiment may be successfully performed; but when the electro-magnet before alluded to was placed with the ends upward, and a long bar of soft iron of a similar shape was suspended over it, with the ends nearly in contact, and a voltaic current passed round the electro-magnet, sounds were emitted from the suspended iron of the usual character, though feeble in degree. This proves, I should presume, that the circuit of a voltaic current round the iron is not essential to the production of sound, but that the vibrations are elicited at the moment of excitement and suspension of the magnetic state in the iron; and the previous experiments go to prove that the iron or steel, in a state most favourable to the development of a magnetic condition is, as might have been expected, the most likely to emit louder and more distinct intonations. In support of this opinion, I may mention that when a bar of iron, which was hammer-hardened or cold-swaged, as it is called (in which state it is of a more sonorous nature), was exposed to the influence of the voltaic coil, and afterwards made red-hot and gradually cooled, and again placed in the same coil, the sounds observed in the latter instance were by far louder and more distinct than those obtained from the iron when it was in the hardened or unmagnetizable condition.

After trying these experiments, I thought it extremely probable that the conducting wire of the voltaic circuit would itself produce vibrations or sounds at the commencement and interruption of the current; and after a few failures I fully succeeded in proving such to be the case. I supposed that the vibrations or tones elicited by the conducting wire would, if produced at all, most probably be feeble in extent: and in order to render them as evident as possible I stretched the wires to be tried across a sounding-board. For this purpose I found nothing more convenient than an Æolian harp, which is upwards of 3 feet long and 5 inches wide and deep, with stretching pegs at each end as usual.

On connecting each end of a brass wire, $\frac{1}{50}$th of an inch in diameter, with an arrangement of 10 cells of Smee's battery, exposing 50 square inches of negative surface in each cell, I observed a distinct sound from the wire, when the circuit was rapidly made and interrupted by an arrangement distinct from the battery.

Digitized by Google

It is obvious that precaution must be taken to prevent the noise or vibration produced by the snapping of the sparks, and by the breaking of contact from communicating itself to the wire or sounding-board: and it can be easily ascertained if this is the case by experiments which will naturally suggest themselves.

On trying the same experiment with copper wire of the same diameter, the sound elicited was more feeble, and could scarcely be detected. This arose, I imagine, from the fact of its being a metal less adapted to produce sonorous vibrations of any sort; and probably, from the same cause, the sound emitted by platinum wire was so feeble that I could scarcely be confident of its existence. With iron wire, on the contrary, the sounds emitted, when the voltaic current was rapidly passed and interrupted, were very clear and distinct; and when an iron wire $\frac{1}{16}$th of an inch in diameter was employed, the sound was sufficiently evident to be observed both on making and breaking contact with the battery; indeed it exactly resembled the tones produced by a bar of iron exposed to the influence of the electro-magnetic coil.

A considerable tension was exerted upon all the wires by means of the pegs; but when the tension was exalted above a certain degree the resonant effect was decreased. I have obtained the sounds from iron wire without any tension at all, merely by suspending a wire with each end dipping in a mercury cup.

These tones, elicited from the conducting wire, most probably arise from like causes with those produced by the electro-magnetic iron bar; as we know that the conducting wire is for the time being in a magnetic condition, or exhibits magnetic effects closely resembling those of the magnetic iron itself. The sounds may possibly be caused by a species of polarity of the particles composing the conducting wire or iron bar; and that polarity not unlikely causes expansion in the wire or bar. But, perhaps, the most simple method of explaining the phenomena in both cases would be to refer to them simply as the results of expansion of a character separate from that produced by calorific action. It was shown some time ago that the electro-magnet expands and contracts at the time when the electric current passes and is interrupted; and it was only at the meeting of the British Association at York that an account was read, from which it appeared that mercury exhibits a similar expansive action when the voltaic current passes through it distinct from that caused by the calorific action of the current.

I have not been able to exhibit the expansion in iron wire

Digitized by Google

traversed by the voltaic current, so as to evolve that produced by calorific action from that caused by the voltaic current independent of such action; but think that it may easily be done if such an expansive action is really produced.

I am, Sir, yours truly,

Rotheram, Dec. 20, 1844. WM. BEATSON.

LXXXIX. *On the Reduction of Brass by the Galvanic Way.* By M. H. JACOBI. From "l'Institut," No. 557.

(TRANSLATION.)

A CONSIDERABLE time has elapsed, (says the author,) since M. de Ruolz communicated to the Academy of Sciences of Paris a process for depositing a galvanic film of bronze upon other metals. This process consists in dissolving cyanide of copper and oxide of tin in certain proportions in cyanide of potassium, and allowing a constant battery to act on the solution. As this process is not very practicable, especially in that the liquor, when exhausted, has need of being almost entirely renewed, I have employed for a long time the following process for preparing by the galvanic way, instead of an alloy of copper and tin, an alloy of copper and zinc, to wit, brass.

With this view, I take a tolerably concentrated solution of cyanide of potassium, an anode of copper and a cathode of another metal, and I act upon it by the current produced by a Daniell's battery, composed of at least two elements. Whilst the liquid is undergoing decomposition, the copper is gradually transformed into cyanide, and is dissolved in the cyanide of potassium. The liquid, therefore, contains a certain proportion of copper; and, as soon as it is sufficiently rich, the copper begins to be deposited in a metallic state on the surface of the cathode. As soon as the first traces of this reduction are perceived, the operation is to be interrupted, and a plate of zinc is to be suspended in the liquid instead of a plate of copper. In this state copper still continues to be reduced; but it gradually loses its red colour, and turns to the yellow of brass. When the desired brass colour has been attained, the zinc anode may be taken away, and an anode of ordinary brass substituted. The cathode, which has only been employed for the first essays, is in like manner removed and replaced by the object, which is proposed to be coated with a film of brass. Brass liquors thus prepared purely by the galvanic way, as we have good

Digitized by Google

reason to say, may be employed for an indefinite period; for this purpose, it is merely necessary to add occasionally a little cyanide of potassium. It is a matter of indifference whether we operate first with the copper, and then with the zinc anode, or inversely. I have frequently used even a brass anode; although by this means I have rarely attained the desired tint. There is always a little copper or a little zinc reduced in excess. If the object is brilliant and polished, the first stratum with which it is covered will enjoy the same properties, and it will not acquire the *matt*, or dead character, until it is thicker, which is the character of the great majority of galvanic coatings. The preparation of the above solution is more readily accomplished in proportion as the solution of cyanide of potassium is more concentrated. When this solution is diluted, it is necessary, both at the commencement of the work as well as for the ulterior reductions, to employ a more powerful battery, one of four pairs and upwards. The colour of the brass may be modified at pleasure; and a very fine film similar to pinch-beck may be obtained by using, simultaneously with the brass anode, a copper anode, with a surface of greater or less extent.

The process which has just been described may be employed with advantage to cover with a film of brass, copper that has been reduced galvanically. It is very convenient for giving to galvanoplastic objects a bronze resembling the ærugo of antiques, which, as we are aware, copper does not acquire without difficulty; but it is especially advantageous when we desire to cover with brass objects of luxury, or those of daily use, which cannot be accomplished by a sort of plating with brass reduced to a very thin leaf—a plating, which, when the forms are a little complex, is a very tedious and expensive operation.

We know that in electrolytic liquids, which hold in solution at the same time several salts with metallic bases—for example, sulphate of copper and sulphate of zinc, or even nitrate of gold or nitrate of copper—the negative metals are reduced much more easily and in greater proportion than the positive metals. In solutions of sulphate of copper rendered impure by a large proportion of zinc or iron, the copper, when action is communicated by means of a feeble battery, is separated almost to the last atoms, without indicating the least admixture of foreign matters. It seemed to me indubitable, that, in the mixture of various metallic cyanides, an entirely opposite phenomenon should be presented; so that, for instance, zinc, although playing the part of a positive metal, would be reduced more easily than copper. In

Digitized by Google

order to communicate a reddish colour to the reduced brass, it is necessary that the copper be constantly present in great excess, and that the action be more prolonged than in the contrary case. However, as accurate experiments on the different circumstances which must present themselves in this case have not yet been attempted, I shall content myself with this simple observation, which may not perhaps be without its use in the practical application of the process that has now been described.

M. Becquérel has claimed from M. de Ruolz priority in respect of the galvanic reduction of alloys, brought about by the aid of certain mixtures in definite proportions; and, with this view, he quotes an experiment which proves nothing. It appears to me that it is not right to anticipate in this manner a discovery which is in other respects very important, both in its relations to theory and to practice, but which remained entirely to be done. With more show of reason, we might consider metallic alloys obtained by my process and by the other merely as mixtures, in some sort homogeneous, similar to the alloys that are in the majority of cases obtained by fusion. By this latter means, we might much more readily establish a determinate relation between the elements than with galvanic alloys, of the formation of which the laws are as yet unknown.

In the reduction of gold and silver, I have for a long time employed an analogous process—namely, I do not prepare chemical solutions of gold or silver; but I obtain them by employing cyanide of potassium, and by the galvanic way, making use of anodes of these metals. Alloys of gold and copper may be obtained in the same manner as that which we have pointed out for alloys of brass, by means of copper anodes in solutions of cyanide of gold, or reciprocally with a gold anode in solutions of cyanide of copper. However, on using simultaneously solutions of gold and cyanide of silver, we find, as experiment has frequently demonstrated, this remarkable circumstance—namely, that for even a very feeble proportion of silver and a great excess of gold, the silver, although constituting the more positive metal, is reduced much more easily; and that, until it is very nearly exhausted, it communicates to the gold a peculiar pale yellow colour, which slightly verges to greenish. From what has been said before, the zinc would therefore act in the same manner.

The objects placed before the Academy by M. Jacobi at the conclusion of this communication are, some of tin and others of iron; they were covered with a thin layer of brass,

Digitized by Google

which, from the variety in tones and colours given to them after their reduction, demonstrates that there exists different relations in the metals constituting the different alloys.—[A.]

XC. *Remarks on certain Apparent Anomalies in the Electric Phenomena produced by Lightning Flashes.* Letter from M. PELTIER. Comptes Rendus, Dec. 16, 1844. Vol. xix, No. 25, p. 1363.

(TRANSLATION.)

IN the account given by M. l'Abbé Chapsal of the storm which burst over the commune d'Ille (Department of Pyrénées Orientales), August 24, 1842, we notice several curious particulars, which M. Arago very judiciously pointed out at the last sitting.

The apparent caprice of the effects of lightning has given rise to many erroneous explanations, through not having sufficiently distinguished what belonged to each of the two orders of electric phenomena; permit me, Mr. President, to offer the tribute of my observations and experiments to the solution of this question.

In January, 1838, I communicated to the Philomatic Society the results which I had obtained by subjecting bars of iron to electric discharges. These experiments placed beyond all doubt that the electricity which traverses a bar of iron does not impart to it magnetism by its propagation; but they, at the same time, demonstrated that an electric discharge acts mechanically on the molecules of the bar, after the manner of percussion and torsion; namely, that if the bar possesses a magnetism developed by the induction of the terrestrial globe, or by that of a neighbouring current, the discharge of a Leyden jar or battery coerces this magnetism, wholly or in part, just as blows do with a hammer; but it does not develope any.

The coerced magnetism is the more considerable in proportion as the bar approaches nearer to parallelism with the dipping needle, and as the discharge has been stronger and more instantaneous. When, on the contrary, the bar is perpendicular to the dipping needle, or to the plane of the magnetic meridian, there is never any magnetism produced, whatever may be the power of the discharge. I will add to what I then published, that an analogous effect is produced

Digitized by Google

when the discharge is passed across the thickness of the bar; the discharge still coerces the magnetism developed by induction, without producing any new magnetism; but this coercitation is much more feeble than the former, because a smaller number of molecules experiences the action of the discharge. In this latter experiment, when the discharge is made transversely, two cases may be presented, which it is necessary carefully to distinguish. If the conductibility is well established, and the poles of the conductors are sufficiently far apart for all the discharge to traverse the bar, there is then no new magnetism produced: there is merely preserved a portion of that which was developed by induction. But if the conductibility is badly established,—if the poles are not very far apart,—a portion of the electricity is discharged across the bar, leaping from one pole to the other; in this case there is always magnetization, whatever be the position of the bar in respect to the magnetic meridian. Under these circumstances, the exterior discharge simply gives rise to the mode of magnetization for which Science stands indebted to M. Arago.

These experiments dissipate all the apparent anomalies of magnetism produced by lightning. There is magnetization, or rather coercitation of magnetism in bars traversed by lightning, if these bars possess induced magnetism at the moment of the discharge; there is none, if the bar is neutral. There is magnetization in bars traversed laterally,—if a portion of the discharge is made at the same time outside the bar,—if there is a spark leaping from one pole of the conductor to the other. There is no magnetization, if the current traverses the bar entire; it may warm it, exalt it to a red heat, solder it to other bars, according to the energy of the current: but there will not be any magnetism developed.

The extraordinary effects of lightning on buildings cannot in like manner be traced, unless by a new creation, to the laws of simple conductibility.

I have frequently insisted on the complete opposition existing between the phenomena of static, and those of dynamic electricity; and I think that the memoir I published in 1838 has greatly contributed to dissipate the confusion, that reigned in this part of the science. When a conductor is sufficient to give a free passage to an electric discharge, we obtain nothing beyond dynamic effects, which are rendered evident by an elevation of temperature, by a vaporization of liquid, if the conductors contain any, by chemical actions, by the direction of the magnetic needle, &c.; but there is no indication of the attractions and repulsions that are peculiar to

Digitized by Google

static electricity. When the conductor is insufficient, the two orders of phenomena exist simultaneously: the dynamic phenomena are produced by the portion which passes through the conductor; the static by the portion arrested by its insufficiency.

The greater portion of the materials that enter into the construction of buildings are in the class of the worst conductors; when the lightning strikes an edifice, there are always, on account of this feeble conduction, powerful actions of static electricity. Not only are the materials of the buildings bad conductors, but their particular arrangement, necessitated by the habitations, still further converts them into conductors excessively unequal. The whole is formed of alternations of plena and vaccua, by the walls, the partitions, and the floors, on the one hand, and by the windows, the doors, the rooms, &c., on the other. Then, to these numerous inequalities are added the iron ties, scattered in all directions throughout the building, in order to consolidate the parts. These portions of good conductors, which arise and terminate in different points of the building, occasion a great number of local static phenomena, by the accumulation, at the extremities, of the electricity, arrested by the inconductibility of the materials that follow. It is in these points of the arrest of the currents, it is between the portions of the floor and the wall which receive these electric surcharges, that the powerful effects of attraction are produced, which tear up the floors, the skirting-boards, or the furniture that may be near the moist soil and the conductor. Then it is that water from vessels or from the soil is evaporated, and adds its conducting quota to all the neighbouring conductions; then it is that light objects are raised, and form the electric dance between the opposed tensions of the floors. The vapour which then arises is not the product of a *vaporization* at a high temperature, as in the former case, it is the *evaporation* of the moist surface augmented by the prodigious attraction acting upon it. When we see a vapour thus rising from the soil, or from vessels filled with water, we can affirm that it is positive electricity radiating from below upward, and that the electric mass, constituting the lightning, is negative; my experiments have proved that the formation of vapour is much more considerable at the surface of a positive than at the surface of a negative vessel, which, moreover, agrees with what is known of the more ready transport of matter from the positive to the negative pole.

I must not prolong these explanations further; but will return to the subject in a special work, with all the details necessary to its elucidation.—[A.]

Digitized by Google

XCI. *Note on a Method of Measuring extremely Short Intervals of Time, such as the Duration of the Impact of Elastic Bodies, that of the Escape of Springs, the Ignition of Powder, &c.; and on a New Means of Comparing the Intensities of Electric Currents, whether Permanent or Instantaneous.* By M. POUILLET. From "Les Comptes Rendus," Dec. 23, 1844, t. xix., No. 26, p. 1384.

(TRANSLATION.)

INTERESTING researches have been made upon the rapidity with which electric and magnetic actions are exercised; but, in general, a sufficient distinction has not been made between what belongs to the fluids themselves and what belongs to the ponderable matter to which they impress motion. This distinction, however, is the more necessary as the proper action of the fluids among themselves is primitive and direct, and is accomplished with prodigious velocity, whilst the action which they exercise on heavy bodies is secondary and indirect; and, from the nature of things, it can only be manifested by movements, the velocity of which is incomparably less. Thus, when a compass needle is in equilibrio under the influence of terrestrial magnetism, and it is seen to deviate by an extraneous cause, as an electric discharge, a flash of lightning or an aurora borealis, we must make a marked distinction between the rapid instant during which the magnetic fluids have been affected, and the slow instant during which our eyes have been able to detect an appreciable motion in the heavy mass of steel of which the needle is constructed. It may very readily happen that, between these two instants, there might be an interval of time equal to a thousand times or to ten thousand times the short duration during which the proper action of the fluids is in existence. The successive phenomena, in these circumstances, may be assimilated, under several relations, with those that are produced in the ballistic pendulum, when the projectile, having only a small relative mass, is, however, animated with a very great velocity. The pendulum may then be so arranged, that its motion, in respect to the short duration of the impact, does not become fairly perceptible until after a considerable time. Thus do we endeavour to appreciate by the pendulum the time during which the projectile acts, although this action, which is here exercised between heavy bodies having masses of finite size and comparable with each other, is undoubtedly of very great duration relatively to the duration of the action which electric fluids exercise directly on each other, or indirectly on ponderable matter.

Digitized by Google

What we determine by means of the ballistic pendulum is the velocity of the translation of the projectile, when we know its mass, and when we know, at the same time, the conditions of the pendulum, and the amplitude of the deviation that it has experienced, under the influence of the impact. Here there are four quantities connected together by simple relations, which are deduced from the laws of mechanics; and three of these quantities being known, the fourth may be determined with greater or less exactness.

The analogy which may be established between the ballistic pendulum and the magnetic needle is undoubtedly very imperfect, because the forces which act in the two cases are of a nature altogether different; however, it is not without its use in order to enable our comprehending the service which may be derived from the magnetic needle for a host of researches to which it has not hitherto been applied.

For example, we may imagine that, if a magnetic needle is at rest, and an electric current acts violently upon it for a very short time—for instance, for a tenth, a hundredth, or a thousandth part of a second—there may result from this single and almost sudden impulse a slow and regular movement of deviation of a determinate and perfectly appreciable amplitude. This movement of deviation, in respect to its cause, will differ from that of the ballistic pendulum; but it will be very analogous to it in its effects,—for it will be transformed, like the latter, into oscillations of various degrees of rapidity. In the latter case, the primitive deviation depends on the construction of the pendulum—namely, on its mass, its length, its *vis inertia*, &c.,—and then on the velocity and the mass of the projectile; and the oscillations which follow, and which are produced by the action of gravity, themselves depend on the first impulse. In the case of the magnetic needle, the primitive deviation also depends upon the construction of the needle —namely, on its ponderable mass, its length, its *vis inertia*, on the quantity and distribution of its free magnetism; then it depends, in like manner, on the intensity of the electric current, and on the time during which it has exercised its action; finally, the oscillations, which are the result of, and which are produced by, the magnetic force of the earth, themselves depend on the first impulse. Thus the mass and velocity of the projectile are here represented by the intensity of the current, and the time during which it has acted; so that the duration of its action may be deduced from its intensity, provided the relative conditions of the needle be completely known.

Consequently, if it is true that an electric current may act

Digitized by Google

in a manner that is regular and identical to itself, for a very brief instant,—such, for example, as a thousandth or a ten thousandth of a second; and if, at the same time, it is true that it may, by this very prompt action, produce on a magnetic system a first impulse,—a primitive deviation sufficiently slow, and of some degree of amplitude—nothing will be more easy than to determine with accuracy intervals of time which are estimated by thousandths and by ten thousandths of a second. In order to obtain such measurements by means of magnetic needles everything is hence reduced to these two essential questions: what is the limit of time necessary for a current to traverse a given circuit? what is the limit of the amplitude of the deviations that it may produce upon the most susceptible magnetic system?

The first question was examined in one of the Memoirs that I presented to the Academy in 1837, on the laws of the intensity of electric currents. I had then established that a circuit of many thousand metres in length was traversed by the current in a space of time that did not amount to $\frac{1}{7000}$th of a second; and that in this very brief instant it was not simply a portion of the electricity that was manifested in the circuit, but that the entire current passed with all its intensity. I am not aware whether, since that period, this class of researches has been extended further. I will therefore admit this result as the limit of what has been, but not as the limit of what may be, demonstrated. On the contrary, I am induced to believe that in a still shorter time the electricity may traverse a circuit of a much more considerable extent. It would be interesting to make experiments on this subject with circuits of three or four hundred thousand metres, as those which are employed for electric telegraphs. By operating on such lengths we should have much greater facilities for finding the limit of the velocity with which electricity is propagated, and also for discovering whether this limit depends on the absolute lengths of the circuits, or on their degree of conductibility.

The second question is not resolved by the first:—from the current's passing in its integrity in $\frac{1}{7000}$th of a second, and from its maintaining in equilibrio the needle of the intensity compass, by its periodic return at very approximate intervals, it by no means follows that a single one of these actions would impress on the needle a sensible and observable deviation. We must, therefore, insulate one of these impacts, in order to ascertain its effect. I accomplish this in the following manner:—

Upon a glass plate, 84 cent. (33 in.) in diameter, is pasted a strip of tin, 1 mm. ($\frac{1}{25}$ in.) wide, extending like a radius from

Digitized by Google

the circumference to the centre; it then communicates with a wider circular band, surrounding the axis of rotation. Suppose that the plate turns at the rate of one turn per second, and that the two extremities of an electric circuit rest by springs—one on the central band, which it always touches, and the other on the glass of the plate, near its circumference. At the moment when the band of a millemetre passes under the latter there will be an electric communication, and the duration of the current will be exactly equal to the duration of the passage of the band—namely, to $\frac{1}{3250}$th of a second if it touches near the circumference; to $\frac{1}{1250}$th, if it touches at the middle of the radius, &c. If the plate makes two, three, or four turns per second, we shall thus obtain passages of a duration two, three, or four times less.

Now, in making the experiments, I have found that an ordinary Daniell's battery of six elements, having to traverse a circuit of about 40 metres (131 ft.) of copper wire, of 1 mm. gives a current sufficiently intense for its action, when operating for $\frac{1}{5000}$th of a second, to produce a deviation of 12° on the needle of a galvanometer, that is by no means sensible; the needle requires about 10 seconds in order to traverse this area, so that the rapid action of the electric and magnetic fluids, which is exercised for $\frac{1}{5000}$th of a second, is by this means found to be transformed into a movement fifty thousand times slower, when it passes into the ponderable matter of the needle.

M. Melloni's galvanometer possesses a sensibility that is now known to all philosophers; it varies in different apparatus. It may, however, be taken as a term of comparison, when our only object is to give an approximate idea of electric effects. One of these instruments gives 15° of deviation, when the current of a single Daniell's element—the circuit of which consists of about 20 metres (65½ ft.) of copper wire of 1 mm. —is made to act on it for $\frac{1}{50000}$th of a second. Thus, with this instrument, we can without difficulty appreciate the ten-thousandth part of a second.

It must be understood that we have here to determine the laws according to which the amplitude of deviation varies in the same instrument with the intensity of the current and the duration of the contact. These laws may be deduced from various theoretical considerations; however, it will be necessary to verify them by precise experiments. Meanwhile, I have confined myself to graduating empirically the apparatus that I have employed—namely, by drawing out a table of the deviations it undergoes, under the influence of a known current acting for a determinate time. This graduation being

Digitized by Google

once made, the galvanometer becomes in some sort a ballistic pendulum, which gives the time during which the same current exercises its action.

Among the applications that I have as yet been able to make of it, I shall simply cite that which relates to the velocity of the inflammation of powder.

The experiment is arranged in the following manner: the two extremities of a circuit, that includes the galvanometer and one Daniell's element, are adapted, one to the cap, as placed on the nipple, and the other to the hammer, all the battery being well insulated from the gun; a portion of the wire passes before the mouth of the gun, at a little distance off, so as to be cut by the ball at the instant when it escapes. This is all the apparatus. When the gun is fired, the current passes during all the time that elapses from the moment when the hammer strikes the cap to the moment when the ball cuts the wire. The deviations produced by various experiments, made with the same charge of powder, are perfectly concordant. The observations are made with the greatest facility; and with the charge that I employed, the extreme values are $\frac{1}{140}$th and $\frac{1}{150}$th of a second, for the time which elapses between the moment when the cap is struck and the moment when the ball escapes from the gun.

By varying the charges, and taking powder of different qualities, and different common guns or rifles, we can easily determine in all cases the period in question.

In order to apply the same principle to the determination of the velocities of a projectile in various points of its course, it is only necessary to arrange on the route a system of silk threads, and further on a system of conducting wires; in such a manner that, on breaking the silk thread, the projectile shall establish the electrical communications; and that, on breaking the conducting wire, it shall interrupt it. The observed deviation will give the time of the passage. Only it is necessary to keep account of the time required for the escape of the spring, which is to establish the communication at the moment when the silk thread is cut. This time is of itself very easily determined, as may also be determined the time of the impact of elastic bodies. This time is very short: in the trials that I made it varied from $\frac{1}{1500}$th to $\frac{1}{2000}$th of a second.

The principle of which I have here endeavoured to give an idea, and to which I call the attention of philosophers, is not only applicable to the measurement of the time during which the most rapid mechanical effects are accomplished; it may, I hope, be of great assistance, as a means of determining the

Digitized by Google

intensities of electric currents themselves, especially the intensities of currents called *instantaneous*—namely, those which are produced by ordinary electricity, and by the phenomena of induction.

The accurate graduation of galvanometers requires very uniform rotatory motions. This uniformity may, undoubtedly, be obtained with clock-work; but I am induced to believe that it might be obtained with greater facility by means of an electro-magnetic machine suitably arranged; and this, perhaps, is the most immediate service that may be expected from this kind of machine.—[A.]

XCII. *On Terrestrial Electric Currents, and on their influence over the Phenomena of Decomposition and Recomposition in the Strata which they traverse.* By M. BECQUEREL. From "Les Comptes Rendus," Nov. 18, 1844, Vol. xix. No. 21, p. 1052.

(TRANSLATION.)

FIRST PART.

CHAPTER 1.—*Attempts made to demonstrate that Terrestrial Magnetism has an Electrical Origin.*

THE cause by virtue of which our planet possesses the property of magnetic polarity has hitherto remained covered with a veil, which the researches of philosophers have not heretofore been able to raise, notwithstanding the numerous attempts made with this intent. It is not by any means my intention to take up this question with the object of solving it; but rather with a view to prove that the facts hitherto observed do not justify the electric origin, which we have endeavoured to attribute to the magnetism of the earth, although there do exist electric currents of which we have mistaken the cause. In order to take a general view of the question, I will begin by setting forth in a rapid manner the hypotheses which have successively been put forth in explanation of terrestrial magnetism.

Gilbert was the first who advanced that the earth was a magnet, the axis of which sensibly coincided with the terrestrial axis. According to this hypothesis, the two magnetic poles should be found at a short distance from the poles of the earth.

Mr. Hansteen advanced, that it was not possible to account for observed phenomena without admitting a second mag-

Digitized by Google

netic pole in the boreal regions; and that hence there ought to exist a second magnet traversing the globe in the direction of a diameter, and the pole of which should coincide with the magnetic pole of Siberia. Mr. Hansteen, by giving free scope to his imagination, advanced the boldest ideas upon the cause of terrestrial magnetism. According to him, the sun should be regarded as possessing one or several magnetic axes, which, according to their direction in relation to the earth, would produce a difference in the magnetism of the latter, and in that of the moon and the other planets. This hypothesis did not rest upon any fact that was capable of justifying it, or even upon any experiment from which a favourable deduction might be drawn. By adopting it the difficulty was only driven back, because we might demand—whence came the solar magnetism?

M. Biot having endeavoured to link together by calculation all the observations that relate to terrestrial magnetism, by considering the earth as a magnet, by taking a determinate value for the distance of the poles, and by setting out from the principle that the power of each of these poles varied in inverse ratio to the square of the distance from the point on which they acted, he obtained a general expression for the direction of the magnetic needle. By varying the indeterminate distance, and comparing the results of experiment with those of calculation, M. Biot found that the nearer the poles were together the more did these results correspond, and that the errors or rather the differences between the results of calculation and the observations were reduced to the minimum when the two poles were infinitely near to each other, and at a very short distance from the centre of the earth. It evidently followed from this that the earth ought no longer to be regarded as an ordinary magnet whose two poles were at its extremities. I will add, that the irregularity of the magnetic lines on the surface of the globe excludes any regular distribution of the magnetism.

We can conceive how important a matter it is to define perfectly the magnetic condition of the earth, namely, its identity with one magnet or with several magnets crossing each other, whose poles are situated in this or that part, seeing that, when the magnetism shall be perfectly defined, the theory of electro-magnetism will indicate the manner in which electric currents should be distributed on the surface of the globe, in order to produce the observed effects.

The deductions to which M. Biot has been led accord very well, as Mr. Barlow has demonstrated, with the hypothesis of a body subjected to a transient magnetism by

Digitized by Google

induction. In fact, from the experiments of the latter gentleman, it follows that the laws of terrestrial magnetism are incompatible with those which belong to a body in a permanent magnetic condition, whilst they perfectly coincide with those which belong to a body in a transient state of magnetic induction. These consequences, we should bear in mind, are important to the theory of terrestrial magnetism, but throw no light on the electric origin of this magnetism.

Up to the period of the discovery of electro-magnetism, the magnetic agent had no connection with electricity. It remained isolated in nature, and it was not possible to attempt any experimental research touching the electric origin of terrestrial magnetism; but it was not so afterwards, although the experiments hitherto made have not thrown any light upon the question. Among the philosophers who have been engaged on this subject, we place in the first rank MM. Ampère and Barlow, who successively put forth theoretical ideas touching the electric origin of terrestrial magnetism.

The first, by assimilating the earth to a magnet, without concerning himself about the position of the terrestrial magnetic poles, nor about the greater or less irregular direction of the magnetic lines, admits the existence of electric currents disseminated over the surface of the globe, and directed from east to west. By aid of this hypothesis, he endeavoured to explain the general direction of the magnetic needle, as well as the diurnal and annual variations to which it is subjected at each spot on the globe, considering the presence of the sun to be concerned in the phenomena by its position above the horizon, and its height at different periods of the year. M. Ampère, by considering the earth as merely a regular magnet, looked at the question under a single point of view. He set out of the question the irregularities presented by terrestrial magnetic phenomena on different parts of the globe, considering them as merely difficulties of detail, which further discoveries might remove. This bold hypothesis, as we shall soon see, cannot be admitted.

Mr. Barlow, without seeking to establish the existence of the currents pointed out by M. Ampère, adopted them *à priori*, and endeavoured to produce all the effects of terrestrial magnetism by means of an artificial wooden globe, on the surface of which he distributed a series of electrical currents, so arranged that their tangential action might in all parts give a corresponding direction to a magnetic needle freely suspended. This globe, the poles of which were placed in the position of the magnetic poles of the earth, produced, it is true, upon a magnetic needle secured against the in-

Digitized by Google

fluence of terrestrial magnetism, and placed in different positions, the same degree of action as the earth would impress upon it in analogous positions. Here, we must confess, was nothing more than a representation of M. Ampère's theory, which regarded the earth merely as a perfectly regular magnet. This theory, moreover, rests on the important result discovered by M. Ampère, that the action of a magnet, to which he compared the earth, upon a magnetic needle is the same as that of electrical currents circulating around each molecule of the magnet in planes perpendicular to its axis.

But, on demonstrating by calculation that the action was the same, namely, that electric currents might be substituted for the action of a magnet, it did not follow that the currents really existed. All that is certain is, that all the attempts hitherto made to demonstrate the existence of these currents have entirely failed, as we shall presently see. M. Ampère, not being able to demonstrate experimentally the substitution in question—namely, the existence of electric currents—endeavoured to render it at least probable. To this end he set out with the hypothesis, that the nucleus of the globe is formed of a metallic bath, covered with an oxidized crust, and that water and divers agents, penetrating by numerous fissures to the bath, produce in it a multitude of chemical reactions, the existence of which is attested by volcanic phenomena. These chemical reactions being once admitted, he had a ground for saying that there would result electric currents, whose energy would be proportionate to that of these same reactions. It must be confessed that we do not see how these currents would be produced; and, if they existed, how it would happen that their result should be directed from east to west. In fact, it is not enough that there be a production of an electric current—that a body reacts chemically upon another body,—a case in which an enormous quantity of electricity is disengaged. It is further essential that the two bodies communicate together by the intervention of a third body—a conductor of electricity that is not attacked by the chemical agents, or at least is only feebly so attacked, relatively to the principal chemical action. It is, moreover, necessary that this third body, in order to produce the terrestrial magnetic phenomena, should be in the direction of the magnetic parallels. Without the presence of intermediate conducting bodies, directed in the manner we have just mentioned, there is merely a tumultuous recomposition of the two electricities that are disengaged by the contact of water and other substances with the metallic bath. Although this recomposition is in general tumultuous, nevertheless, under certain circumstances that we are about to

Digitized by Google

point out, electric currents are produced, which assume a thousand directions.

The greater portion of the solid compounds of which the crust of our globe is constituted are oxidized bodies—bad conductors of electricity, and which, on that account, cannot concur in the production of electric currents. But it is not the same with the metallic substances, which fill the loads and veinules, that are found in a great many localities, and the quantity of which, it must be granted, is very small in comparison with that of the rocks of which the crust of the earth is composed. These metallic substances, moreover, very rarely form conductors of any extent, inasmuch as they are interrupted by quartz or other non-conducting gangues. Nevertheless, wherever these substances exist, and when they are in communication with the sources of electricity, partial currents will be the result, which cannot assume any fixed direction, unless in some very limited cases. The loads, veins, and veinules, when they contain conducting substances, may establish the electric communication between the metallic bath and the liquids, or other agents, that arrive from the surface of the earth, by the innumerable interstices growing out in all sorts of directions. Such are the electric currents which, according to M. Ampère's ideas, may circulate in the crust of our globe, and the resultant of which cannot be directed from east to west as he has advanced. I shall only add, that if this resultant existed, it could not be influenced by solar heat, for the latter cannot exercise its action in the cavities of various depths in which the mechanical actions in question are brought about.

It is therefore demonstrated that the existence of electro-chemical currents circulating from east to west in the crust of the globe, and imagined by M. Ampère for the explanation of terrestrial magnetic phenomena, cannot be admitted. We shall see presently that there exist other causes than those that have been pointed out, which are capable of producing electro-chemical currents, often of a very energetic character, and which, notwithstanding, cannot in any degree contribute to the production of terrestrial magnetism. It now only remains for us to examine whether, perchance, M. Ampère's currents might not have a calorific origin. We know that the slightest difference of temperature between the points of junction of two plates or bars of different metals, forming a closed circuit, is sufficient to disturb the equilibrium of the electric forces, and to produce thermo-electric currents. We also know that these same effects are manifested in simple bars of bismuth, antimony, or zinc,—namely, in a metal that crystallizes by cooling. The first condition, in order that these may

Digitized by Google

be productive of thermo-electric effects, is that the circuits be continuous, and composed of conducting substances, such as the metals, anthracite, and some mineral substances; this rarely occurs, because they are often interrupted by badly conducting bodies. A calorific origin, therefore, cannot be attributed to terrestrial currents. The same difficulties present themselves relatively to the production of currents, due to the difference of temperature existing between the central nucleus of the earth and the solid crust that covers it, the temperature of which goes on successively diminishing to a certain distance from the surface. These are the motives which have long prevented my adopting M. Ampère's ingenious ideas touching the cause to which terrestrial magnetism must be traced.

Although the preceding considerations must have struck all philosophers, nevertheless a great number of experiments have been made in order to establish the existence of terrestrial electric currents, as well as their direction, in the hope of making them play an important part in the explanation of terrestrial magnetism, of the filling up of loads, and of the changes that are continually being brought about in our globe. Here the question changes its features. It is no longer theoretical views—simple hypotheses—that we are engaged in examining, but rather facts, the value of which must be determined in order to show how far the consequences that are deduced from them have foundation. The error which has been fallen into, in directing attention to investigations of this kind arises, we must acknowledge, in great part from the traces that the contact theory has left in the science.

Let us enter into a few details on the observations which have been made relatively to terrestrial electric currents.

Among the substances which are commonly found in loads, and which, by their conducting properties, have particularly fixed the attention of experimenters, we may mention iron-pyrites, copper-pyrites, arsenical pyrites, peroxide of manganese, magnetic iron, arsenical cobalt, galena, silver, copper and metallic gold, &c. &c.

It is very certain that when two of these substances, taken at hazard, are in contact and are moistened by a liquid capable of attacking one of them, there is a production of an electric current. Under these circumstances the contact serves only to establish the circuit, but the cause of the disengagement of the electricity resides in the chemical reaction of the liquid upon the solid body. This was not taken into account in the experiments made in the loads of Cornwall. The nature of the electric currents, produced by the contact of two of the substances

Digitized by Google

mentioned above, when plunged into divers liquids, was first sought after. From these experiments the following consequences were drawn:—The different minerals that are commonly associated in the same loads agree in this respect, that their reciprocal voltaic action is generally very small, and that, if it were otherwise, the appearances of decomposition in the same locality would be much more marked and more general than they in reality are. Now none of these consequences can be admitted, because the attention has been directed to simple contact alone (which is incapable of itself to disengage electricity), and not at all to the influence of the active liquid on one of the substances in contact. By omitting this indispensable condition all the consequences that have been drawn from observed facts are tainted with error.

I now arrive at the experiments undertaken with a view of rendering evident the electro-magnetic properties of the metalliferous loads of Cornwall. The apparatus employed by the first experimenter for studying these properties was composed of small copper plates, fixed by means of iron nails upon the sides of the open galleries in the loads, or strongly pressed on the same sides by means of wooden stays; these plates, being put in connection with the two extremities of the wire of a multiplier, were placed in an infinite variety of positions; and each time a note was taken of the direction and intensity of the current. The following are the principal facts that were observed:—the intensity of the current varies according to the localities; sometimes the deviation of the magnetic needle is feeble, at other times it is very considerable; in general, it is greater in proportion as the load contains a greater quantity of copper, and perhaps even in proportion to the depth of the stations. The action is nothing, or scarcely sensible, according as there is absence or but a small quantity of metallic substances. There is not any action when only a few metres in a horizontal direction exist between the plates, and when there is found between them a great quantity of copper uninterrupted by non-conducting substances; but if, perchance, quartz or clay exists in the load the action is generally very marked; it is the same when the two plates are placed at different depths in the same vein or in different veins. The currents are directed sometimes in one direction, sometimes in another. By comparing the loads or parallel veins, it was thought that positive electricity would be observed directing itself from north to south; although, in certain cases, the contrary occurred.

In veins directed toward the north, the east is generally

Digitized by Google

positive and the west negative. Finally, on comparing the state of loads at different depths, it was thought that the lower stations could be recognised as negative in respect to that above, without, however, this being a general rule; because the contrary occurs when a transverse vein of quartz or clay is interposed between the plates. By this we see that there is no regularity in the range of the observed phenomena. In another series of experiments, made subsequently to those above described, by employing the same means of experiment, results very nearly similar were obtained. Only, in addition, it was observed that in loads which produced tin alone, and of which several are in contact with copper, no traces of a current were perceived, unless when the intermediate space is filled with a rich copper ore; moreover, the presence of electricity is more marked when the vein contains copper-pyrites, vitreous copper, black copper, galena and blende; and it is inappreciable when no metallic parts exist; finally, that veins containing copper-pyrites, grey copper, and galena, and others containing carbonate and phosphate of lead and grey copper, give no indication of any traces of electricity. Among all these facts, there are some which may be exact, and others whose origin has undoubtedly been mistaken; for instance, how have the experimenters acted in order to establish the existence of the currents? They have taken two copper plates in any condition, and after having applied them to the sides of the galleries of the mine, they have placed them in connection with a multiplier. Now two plates of copper always produce an electric current in their contact with water, providing their surfaces be not perfectly identical. As this identity very rarely occurs, the electric effect is the more marked as the water contains more salts in solution, which have the power of reacting chemically on foreign bodies adhering to the surfaces. The same occurs if, for the two plates of copper, we substitute two platinum plates whose surfaces are not identically the same. In the experiments made in the mines of Cornwall, the secondary effects, of which I have just pointed out the cause, were not distinguished from the direct effects. We may very readily perceive that water, more or less charged with the different substances, that adhere to the sides of the galleries on which the copper plates were placed, must have reacted with various degrees of energy, according to the nature of the salts contained in the water, upon the copper and upon the iron nails that were employed to fix them; whence, consequently, there have resulted electric currents, often of a very energetic character, which must have been confounded with, have disguised entirely, or have par-

Digitized by Google

tially destroyed the currents of which I have spoken, and upon the existence of which experimenters had not any idea.

I lay down as a first principle, and I will prove it, that there is frequently an enormous quantity of free electricity in the earth at every instant, in consequence of chemical reactions that have not as yet been taken into account, which is capable of producing chemical effects, whenever it meets in its course with conducting bodies whose presence is indispensable for determining the production of electric currents.

The production of this electricity enters into the general law which regulates the liberation of electricity in chemical actions. In order to obtain a clear idea of this production, it is advisable to describe in few words the materials of which the superficial crust of the globe is constituted. This crust has been divided into four great divisions or formations, in reference to the relative age of each, to the nature and composition of the substances of which they are formed, to the presence or absence of organised bodies, or their remains serving to characterise them. Each of these formations is itself formed of a great number of other formations, sometimes separated by clays and sands, or other substances permeable by water. All these strata, in consequence of upheavings or commotions, which the crust has undergone at divers epochs, have been more or less dislocated and split in an infinity of directions, so that the greater portion of these strata give free passage to water which, being charged with air and holding various substances in solution, moistens the sides of these clefts, and consequently their encasing rocks, and in a greater or less degree determines their decomposition. If, for example, we consider in succession the four great orders of strata studied by geologists,—the tertiary, the secondary, the transition, and the primary strata,—we see, in all directions, traces of the decomposition, to which we shall advert in the second chapter of this memoir, in order to show how far electricity may be concerned in their production.

If we consider, in the first place, the tertiary formation, we first of all find alluvian and diluvian strata composed of gravels, sands, and clay, &c. &c., all very permeable to water, and consequently able to serve for transmitting to great distances electric currents, due to any cause. Lower down are manifested the fresh and the salt water limestone, which, when they are perfectly compact and without fissures, do not permit of the passage of water, or at least permit it with great difficulty, which however is a very rare case,—but the lower parts of which, being separated by siliceous sands or clayey-marls, are conductors of electricity, on account of the

Digitized by Google

water by which they are impregnated. Lower still we meet with beds of gypsum, also separated by marls of various degrees of humidity, able in like manner to serve for the transmission of electric currents to very great distances. Finally, beneath these is found the plastic clay, penetrated by moisture, and able in like manner to contribute to the transfer of electricity.

In the secondary strata, each of their divisions presents to us limestones with their clay, their sand, or their sandstone, able to serve for the transmission of electric currents.

In the transition strata, there exists a series of alternate beds of coal, schiste, sandstone, and rocks of various natures, sometimes separated by clay, and consequently presenting here and there parts permeable in various degrees by water.

In the primitive strata, from the very nature of the rocks of which they are composed, water cannot penetrate except by cracks or fissures, resulting from dislocations that have taken place, from up-heavings of the earth or from earthquakes, or else in virtue of successive decompositions due to the action of water, air, and other chemical agents.

With regard to the loads,—these, as we are aware, are clefts of great extent made, for the most part, in the ancient periods, and subsequently filled with metallic substances and stoney compounds called *gangues*. These fillings-up have been brought about either by means of fire, by volatilization, or by means of water and deposits derived from the surface of the earth. These loads almost always afford a passage to water containing different salts or compounds, derived from it sreaction on the substances, with which it meets; and which frequently annoys speculators.

From this short exposition, we see water is found in greater or less quantity in the divers formations of the superficial crust of our globe, and principally in the parts composed of sand, clay, porous rocks, rocks that are cracked or are in a state of decomposition, and finally, rocks that are permeable to water by means of capillary action. As these strata often extend to very great distances, if there exists in the earth electricity having a sufficient tension, they may serve to transmit it afar, and even to the metallic substances which fill the loads, and the greater portion of which are conductors of electricity.

But from the very fact that we find within the earth liquid and solid conductors, as well as causes that liberate electricity, as I am about to demonstrate, it does not follow that electric currents exist; for, in order that they should be

Digitized by Google

manifested, there must exist closed mixed circuits, in which at least one solid conducting body is found. Whenever this condition is not fulfilled, there is not any thing further than a tumultuous recomposition of electricity. Let us now see what the causes are that may give rise to a liberation of electricity in the earth, as well as what the circumstances are that bring about the production of currents.

I will confine myself especially to the clays, which by their nature are peculiarly applicable to my views; it will then be easy to extend the observations that I shall have made to other strata permeable by water. I will suppose a vast extent of moist argillaceous earth, one portion of which contains sulphate of lime, and the other is without it; it is very evident that the water, by which the former is moistened, will become charged with sulphate, whilst the other will be without any. What results will flow from this? The water, charged with sulphate of lime, will react upon that, which does not contain any, so as to give up to it a portion of the compound that it holds in solution; this reaction, we can readily understand, will be brought about over the whole surface in contact. During this reaction there will be a liberation of electricity such, that the saturated water will set free positive electricity, and the unsaturated negative. These two electricities will combine tumultuously at the surface of contact, in order to form the neutral fluid, without there being any electrical currents. Suppose now that vegetation is developed at the upper part of these clays, roots and radicals will penetrate into the interior to very great depths, of which indeed we have frequent proofs in examining these beds. From the moment that vegetation shall have ceased the roots will be decomposed, and will be changed into carbonaceous matters that are conductors of electricity. These relics of roots will be so many conductors for determining the circulation of the electric fluid; but, as the roots and radicles assume a thousand varied directions, it follows that there will be an infinity of small currents, the resultant of which will change from one point to another. Let us, in imagination, substitute for those decomposed roots, the pyrites that are frequently found in clays, or the other conducting mineral substances that are brought by the waters and deposited by them, such as peroxide of manganese, &c., all these bodies will fulfil the same functions as the decomposed roots, and will be, in like manner, the place of an infinity of electric currents, capable of producing the electro-chemical effects, of which I shall speak in the second chapter.

Digitized by Google

In the present state of things, it is not possible for us to conceive terrestrial electric currents as having any other origin than that which I have now pointed out; experiment has come in support of all my conjectures.

We can readily perceive that instead of clay I might have taken any other rock permeable to water; in like manner, instead of sulphate of lime, I might have admitted that the water contained any one of the substances with which it is generally charged in traversing different strata. Now suppose that for the decomposed roots, the pyrites, or other conducting substances, we substitute two platinum plates, perfectly homogeneous, and in connection with a multiplier, and that one of these plates is introduced into the clay moistened with a solution of sulphate of lime, or other substance, and the other into the clay containing nothing but pure water it is very evident that the former plate will seize upon the positive electricity liberated by the saturated liquid in its reaction on that which is not so, whilst the other plate will seize upon the negative electricity. Hence will arise an electric current that will manifest its action on the magnetic needle so long as the platinum plate shall remain unpolarized.

Well, I have made a great many experiments in order to establish the existence of electric currents due to the cause that I have just pointed out; they have all given me the most satisfactory results; but as it is useless to cite too many of them, I shall confine myself to relating the three principal series that I made last summer in France, in Switzerland, and in Savoy, under circumstances the most fitted for furnishing clear evidence of the principles that I have now laid down.

I operated, first, on an extensive bed of clay, one portion of which was saturated with chloride of sodium, and the other contained none, or very little; second, on a stratum that was a conductor of electricity, one portion of which was at the temperature of 0° [32° Fah.] to a certain depth, and the other was at 10° [48° Fah.] or 12° [53° Fah.]; third, on two portions of strata, of which the temperature of one was 40° [104° Fah.] that of the other 12° [53° Fah.], the conditions in the first and the third cases were the most fitted for giving energetic currents.

First Series of Experiments.

The experiments of this series were made in the rock-salt mine of Dieuze. It is well known that rock-salt in this locality, as well as in all analogous beds, is found in striated marls, and that the beds of this substance alternate with beds

Digitized by Google

of clay containing more or less of the salt, as well as a small quantity of water, in a greater or less degree of saturation. I was therefore under the most favourable conditions for obtaining energetic currents; I placed myself in a gallery cut in a bed of the rock-salt, the height of which was about 4 mètres (13 ft.): the sides of this gallery, as well as the roof, are of rock-salt, and the soil is argillaceous, although the air is very dry; the sides and the soil contain enough water to conduct electrical currents.

First Experiment.—The multiplier having been firmly placed on a plank resting on the soil, a platinum plate, not in a state of polarization, connected with one end of the wire, was applied to one of the walls of the gallery, and the plate, connected in like manner with the other end of the wire, was introduced into the clay of the soil at a distance of 55 mètres (180 ft.) The magnetic needle was driven violently from its position of equilibrium, and struck against the stop, remaining at 90°. The direction of deviation was such that the plate in contact with the rock salt acquired positive electricity; a result which is easily explained when we take into account the reaction of saturated water upon that which is not so, through the intervention of the strata of clay or marl, by which they are separated. To put this explanation beyond all doubt, I made the following experiment:—

Second Experiment.—One of the plates was applied to the soil, and the other, in like manner applied to the soil, was placed at a distance of 77 mètres (252 feet). I poured a small quantity of water, saturated with salt, upon the very spot where the second plate was placed. The current, at the moment when the circuit was closed, was so intense that the needle was driven with great violence against the stop, and continued to be agitated. Its deflection was in the same direction as before, namely such that the plate in contact with the clay, moistened by saturated water, acquired positive electricity. The experiment was repeated with like success at a distance of 150 (492 ft.) and even 200 mètres (656 ft.) I have no doubt that the results would have been the same at much more considerable distances.

Third Experiment.—This time each plate was held between the fingers slightly moistened with water, by a person placed exactly at the spot, where each plate was in the preceding experiment. The results were similar, and of about the same intensity. In this case, the bodies of the two observers served as conductors of the electricity liberated in the reaction of the saturated solution upon that which was not so. Now, as the human body is a bad conductor, it followed that, under these

Digitized by Google

circumstances, the tension of the electricity was sufficiently powerful to overcome the resistance presented to it.

Fourth Experiment.—The plates were placed this time in such a manner that the results should be much more striking than in the preceding experiments. One of them was placed upon the rock-salt, the other at 130 mètres' (426 ft.) distance, in the soil outside the mine, the conducting wire traversing the shaft. In this manner, the first plate was in contact with water saturated with the salt, whilst the other was in water that did not sensibly contain any; the needle was still driven with violence in a direction announcing that the electrical effects produced were due to the reaction of the saturated solution upon the water that moistened the vegetable earth at the surface of the soil; this reaction was brought about step by step, by means of the water that moistened the intermediate clays and beds of rock-salt. The entire stratum, between the soil and the great bed of rock-salt is composed, as I have already said, of alternate beds of rock-salt and clay. This experiment therefore, and those that precede it, demonstrates, in the most evident manner, that the electrical effects obtained arise from a chemical reaction, the nature of which was well determined, and that they might be transmitted to great distances. But without the employment of platinum plates for forming a closed circuit, there would have been no electric currents, providing there were not present in the clays any bodies, conductors of electricity, similar to those already mentioned. The facts observed in this series of experiments fully confirm the explanation that I have given of terrestrial electric currents.

Fifth Experiment.—The masses of rock-salt in contact with the beds of clay moistened with water being of vast extent, and being good conductors, it is not surprising that, when they reacted on each other, the platinum plates have collected a considerable quantity of electricity; I therefore found myself in the most favourable circumstances for having a current that might bring about electro-chemical decompositions. I did not allow the opportunity to escape of verifying this fact: two platinum plates were placed at a distance of about 80 mèters (262 ft.), one in the soil of the gallery, the other applied with pressure on one of the lateral walls. To each of these was affixed a platinum wire, to which was attached a copper wire, terminated by a platinum wire. These precautions were taken in order that the salt water, by which the plate was moistened, should not attack the copper wire. The same precaution had been taken in the preceding experiments. The two free extremities of the two wires were placed on a

Digitized by Google

slip of paper prepared with starch, and moistened with a solution of iodide of potassium; the presence of iodine was not long in being manifested around the wire forming the positive pole. The tension of the electricity, therefore, was sufficient to bring about a chemical decomposition. I should remark that all the experiments were repeated by inverting the plates, namely, by putting one in the place of the other, and reciprocally, in order to guard against the effects of the accidental polarization that plates of platinum always present, when they have acted for some time.

I may add that the plates which I employed were squares of 6 cent. (2·36 in.). Had I employed large plates, and had I allowed the collected electricity to pass into a saline solution by means of two fine platinum wires, I could have conceived what the energy of the decomposing force might have been. By operating with platinum plates I was placed in an unfavourable condition, but if, instead of that which acquired negative electricity from the earth, I had employed a zinc plate, a current might have been obtained capable of producing all sorts of decompositions.

Second Series of Experiments.

First Experiment. — The experiments made in the salt mines of Dieuze were repeated on the *mer de glace* of Montanvert, above the valley of Chamouny, by following exactly the same indications, and with the same multiplier, platinum plates, and wires, that had already been used. One of the platinum plates was stuck to a block of ice, the other was introduced into the earth at about 50 mètres' (164 ft.) distance. The temperature of the earth, where the plate was situated was then about 11°, [52° Fahr.] The magnetic needle was driven by the first impulse to 40°, and settled at 12°. In a second experiment, the result was sensibly the same. The direction of the deviation indicated that the plate, placed on the block of ice, had acquired negative electricity; on holding, as was done at the salt-spring of Dieuze, between the fingers the platinum plate, which had been introduced into the earth, the magnetic needle was deflected in the same direction, but not so much as before,—the deviation by the first impulse being only 20°. In order to the production of this effect, the tension of the electricity must necessarily have been very considerable, notwithstanding the bad conducting power of the human body. The direction of the electric current indicated that the electrical effects were not derived from the reaction of cold water upon warm; for, had that been the case, the current would have been determined in the

Digitized by Google

contrary direction; it follows, therefore, that they were due to the reaction of the different liquids, with which the strata were saturated, and which occurred in the circuit, of which the platinum plates formed a part. To be sure of this, I operated in the following manner:—

Second Experiment.—The plate, which had been placed in the earth in the preceding experiment, was put in contact with a second block of ice, situated at about 60 mètres from the former. The deviation still occurred in the same direction. The two plates were evidently at the same temperature; consequently, the electrical effects must have arisen from a chemical reaction, and not from a calorific action. I should observe that the currents, obtained on the glaciers, had a very feeble intensity compared with those obtained at Dieuze, because the ice, being a bad conductor, could transmit only a feeble portion of the electricity liberated in the reaction of the inferior strata. It is probable that if the sun, which was then shining, had not melted a small quantity of the ice on the surface of the blocks, the latter would have been deprived of all sensible conducting power.

Third Series of Experiments.

I felt it a duty to repeat the same experiments in a locality where the differences of temperature were much greater. I consequently chose the bathing establishment of Aix in Savoy, where the temperature of certain springs rises as high as 50° [122 Fahr.]

First Experiment.—After having made the same arrangements as before, one of the plates was plunged in the spring water called sulphur water, the temperature of which was about 43° [109° Fahr.], and the other in pure water, running at the surface of the soil, the temperature of which was about 13° [55° Fahr.] The distance of the two stations was 4 mètres [13 ft.] in elevation, and 6 mètres [20 ft.] longitudinally. At the moment, when the circuit was closed, the needle struck violently against the stop at 90°. The direction of the deviation indicated that the plate, plunged into the hot sulphurous spring, acquired negative electricity, which indicated that the electric effects might be derived from the action of hot water upon cold; the effect was still the same, on inverting the plates, so as to guard against the secondary effects of polarization.

Second Experiment. — One of the plates was placed in the alum spring, the temperature of which is a little lower than the preceding; the other, in the water of a brook flowing at the surface, and the temperature of which was 13°

Digitized by Google

[55° Fahr.] The magnetic needle was still strongly deviated; for it struck against the stop placed at 90°. It is beyond doubt that, had I endeavoured to produce chemical decomposition, I should have obtained the same effects as at Dieuze.

These three series of experiments were made under circumstances the most favourable for showing what the causes are, by virtue of which electrical currents are obtained in mines, when not using, as has been the practice hitherto, copper plates that give secondary effects due to the chemical reaction of the liquid upon the metal, but rather platinum plates with perfectly homogeneous surfaces.

If we transfer ourselves to a load of galena or copper-pyrites that has been worked, and take our multiplier and the platinum plates affixed to wires of the same metal, and operate, as I had previously done, we might predict beforehand the direction of the current, as soon as we were made acquainted with the nature of the waters that moisten the sides of the galleries and the surrounding strata.

The explanation that I have just given, of the production of terrestrial electric currents rests on facts, of so conclusive a character that I believe it entirely free from all objection. It is now, therefore, proved that these currents do not really exist, except when two contiguous strata, of any nature, are moistened,—when the water of one holds in solution compounds that are not found in the other, and when both strata are traversed by conducting substances, such as carbonaceous matters, pyrites, galena, &c. If all these bodies do not form continuous conductors, there will be many partial currents, and consequently as many centres of decomposing action, as there are separate conductors. I have a few observations further to offer, and which are not without importance under present circumstances, when the establishment of electric telegraphs occupies attention in all quarters, as also the possibility* of employing the earth as a conductor.

The existence of terrestrial currents may be established, as I am convinced, in an immense number of localities, where notable differences in the nature of the strata are not suspected, and this simply in consequence of the waters by which they are moistened. For this purpose, nothing more is required than to place in any stratum, at the distance of a few mètres, two very clean platinum plates connected with a multiplier; the deviation of the magnetic needle will almost

* There is no possibility,—that is, no probability,—on the subject; the earth *is* employed, and has long been so.—Ed.

Digitized by Google

always indicate a difference of composition in portions of strata, that appear identical.

By substituting a plate of zinc for the platinum plate, that acquires from the earth negative electricity, the current resulting from the action of the former will be added to that furnished by the earth, and the electro-chemical effect will become very much manifested. From this it may be perceived that, when a current is transmitted through the earth by means of two plates of metal, this current may be added to the local current, or may pass in the opposite direction; its intensity is thus augmented or diminished. We should not omit paying attention to this consideration, when we desire to obtain a maximum affect.

It might also happen that energetic sources of electricity, such as those which I found in Loraine or Savoy, situated between the electrodes or rheophores, would be discharged, although at great distances, by the intervention of the moist beds, that separate them from the said electrodes.

Finally, I may add that we should not be astonished at the enormous quantities of electricity collected in my experiments with very small platinum plates, when we reflect that the sources, whence they emanated, were of very great extent, and they must have given them up for the very reason of their extent.

In a second memoir, I shall examine the chemical effects produced on the rocks and the other substances which they contain by the currents whose origin I have now pointed out; and also the secondary products which are the result.—[A.]

XCIII. *On the Conductibility of the Earth for the Electric Current.* Letter from M. Ch. Matteucci to M. Arago. From "Comptes Rendus," June 3, 1844, vol. xviii., No. 23, p. 1032.

(Translation.)

Having latterly been desirous of repeating Mr. Wheatstone's beautiful experiments, which have confirmed in so luminous a manner, the discoveries made in Germany by MM. Fechner, Jacobi, Poggendorff, &c., and in France by M. Pouillet, an opportunity occurred to me for studying the conductibility of the earth in a more complete manner than had yet been done. For these experiments, I had at my disposal a copper wire 7000 Tuscan *bras* (4440 yards) in length. This wire was the

Digitized by Google

No. 8 of commerce; the weight of a yard was 66 grains troy. The galvanometer that I employed was Nobili's comparable galvanometer. I am in possession of the very instrument with which that philosopher prepared his memoir. In the course of my experiments, I have had occasion to verify the accuracy of the table of intensities given by M. Nobili to his galvanometer. Instead of having the wire covered with silk and made into bobbins, I extended it along a meadow, keeping it raised above the soil with thin stakes of dry wood, about four feet high, over the surface of which I had spread three layers of varnish. The stake was driven into the earth, 8 or 10 cent. (3 or 4 inches) and the wire was turned once round the summit of the stake. The electromotor that I employed was always a single Bunsen's element, in which I had only rain water, in contact with the carbon and amalgamated zinc; for I removed the clay cylinder, and prevented contact between the zinc and carbon, by means of three strips of wood tied round the zinc. I found that the insulation of the wire by the stakes that I have described was perfect. When the circuit was composed of 7000 *bras* (4440 yards), the intensity of the current was the same, whatever might be the point of the circuit in which the galvanometer was introduced. The pile gave me a constant current for several days; I merely renewed the water occasionally, and passed a piece of linen over the zinc. I should here mention that Nobili's comparable galvanometer is not very sensible. I commenced a long series of experiments, by merely adding to the circuit of the battery variable lengths of copper wire. I was thus able to determine the *reduced* length, which represents the resistance of the pile; and I verified, at least for the entire length of 4440 yards, the expression of the resistance of the additional circuit, such as it is now generally received. I was in the same manner, able to verify the table of intensities given by Nobili for his galvanometer. I will now describe the experiments that I made in order to study the conductibility of the earth:—I plunged into a well a large iron plate, to which the copper wire was soldered. The surface of this plate, in contact with water, was nearly 3 square metres (3½ square yards.) Another similar plate was arranged in like manner in another well. In the first experiment, the two wells were at a distance that might be estimated, in a right line, at 28 *bras* (53 feet). I closed the circuit first without introducing the pile, and with the galvanometer alone, I obtained a deviation of 4° or 5°, which immediately diminished; but never did it entirely disappear. By raising and immediately replunging sometimes one, sometimes the other plate, I observed the di-

Digitized by Google

rection of the deviation vary; and, on leaving the circuit closed, the needle returned to zero. These, then, are the phenomena that are obtained on plunging into a liquid two plates of the same metal, connected with the extremities of the galvanometer. I introduced the pile into the circuit, beginning from zero; and the deviation that I obtained gave me the reduced length in copper wire, which represented the resistance of the portion of the circuit composed of the iron plate, the water of the well and the bed of earth. I found that this resistance of the portion of the earth, whose length in a straight line I have given, of the water of the wells, and of the plates, was 809 *bras* (1537 feet) of my wire. I had recourse to two more distant wells: their distance in a straight line was 360 *bras* (684 feet); and I compared the intensity of the two currents, when I had in the circuit, in the one case, 360 *bras* of wire, and the earth between the two wells 28 *bras* (53 feet) from each other, and in the other case the same 360 *bras*, and the earth between the two wells distant apart 360 *bras*. I obtained in the two cases exactly the same current. I added, in each case, variable lengths of copper wire; and found the resistance due to this wire such as is given by theory. I selected wells at a still greater distance apart; and made the same experiment. In this third case, the circuit was composed of 780 *bras* (1482 feet) of wire, and of the earth between two wells 518 *bras* (984 feet) apart in a straight line. The pile employed in this case gave a constant deflection of 26°, without any additional circuit. In a fourth experiment, I had 1120 *bras* (2128 feet) of wire, and the earth between the two wells of one of the preceding experiments, 360 *bras* apart. I obtained in the former case 17°·5, and in the latter 16°·7: in the former experiment, I had more earth and less wire in the circuit; in the latter, it was the reverse. I confirmed these results twice; and I have no error with which to reproach myself in the experiment. It evidently follows from this that a bed of earth of greater or less length presents the same resistance; that this resistance of the earth occurs at the first introduction of the current into the earth: and that, by operating at greater distances, such distances that the resistance of the added copper wire is sufficient to diminish the force of the current more than it had been diminished by the first introduction of the current into the earth at a very small distance, this resistance of the earth disappears. These first experiments induced me to operate on a larger scale; and for this purpose, I betook myself to the high road that passes for $4\frac{3}{4}$ miles through the park of the Grand-Duke, very near to Pisa, and which abuts on the sea.

Digitized by Google

I operated in a similar manner by plunging the plates into wells:—I need simply mention that, in a first experiment, made between two wells 4885 *bras* (9281 feet) apart, and with an equal length of copper wire, I found that the insulation of the wire was not perfect, as I had not employed the stakes described above. Instead of this, I had fixed the wire round nails placed from distance to distance on the trees of the high road. I then discovered that, even when the plate of the opposite station to that at which the pile stood was not in the well, I obtained a deviation, a small one however, with the galvanometer. But when I employed varnished stakes, the nsulation of the wire was perfect, the needle returned exactly to zero, when the circuit was broken at the distant station. In like manner, I saw, with two galvanometers, at the two extreme stations, that the deviation was the same, both very near to the pile, and at 4885 *bras* distance. I should mention that the circuit is not entirely broken if we merely take the plate from the well and throw it on the ground, while it still remains soldered to the copper wire. The following numbers were found in one of the experiments that I made. The Bunsen's element, with the wire of the galvanometer alone, which is 10 *bras* (19 feet) long, gave a constant current of 17°, equal in intensity to 36·78. When the circuit was composed of 4885 *bras* without earth, I had obtained 6°·5, which is exactly the number given by theory, being equal to 7·5 of intensity. I closed the circuit with the same length of wire and the earth by means of plates plunged into the two wells.

The needle immediately started from zero, and I had in my galvanometer a constant current of 8°. The galvanometer at the other station indicated exactly the same deviation. The observers, who were placed at the two extreme stations, interrupted and established the circuit at determinate times. When the circuit was interrupted, the needle returned to zero. I avail myself of the present opportunity to return thanks to my colleagues and friends, MM. Pacinotti, Ridolfi, Sbragia, Cima, and Ruschi, who were so good as to assist me in these experiments. In a second experiment, I obtained exactly the same results, which may be thus summed up:—By making a current circulate in a copper wire 4885 *bras* in length, and through a bed of earth of the same length, the diminution, which occurred in the intensity of the current, is such that the resistance of the bed of earth must not only be regarded as nothing; but further, we must regard the resistance of the copper wire that enters into the mixed circuit as less than that presented by the same wire when it enters alone into the circuit. This fact is singular. The following are the efforts I

Digitized by Google

made to explain it:—I doubted first whether there might be a current with the plates alone, as they lay plunged in the wells, although very far apart, without the pile; I, therefore, made the experiment, by closing the circuit with the earth and the wire without the pile. My galvanometer gave me a deviation which did not exceed 1°, and which was not long in disappearing, if the circuit was kept closed.

I could not, therefore, explain the difference that I had discovered, by means of a current due to the plates alone. The direction of the high road, along which the wire was extended, is exactly east and west: in the first experiment the battery current passed along the wire from east to west. We, therefore, thought that the fact might be explained, by having recourse to a current derived from Ampère's terrestrial currents. Nothing could be more attractive than this idea. The direction of the battery current was inverted: we ought to have expected a diminution of the current, but it was constant at 8°. Notwithstanding this, I lost no time in having the wire extended along the coast, in a position perpendicular to that of the high road. The circuit was the same—namely, it consisted of 4885 of wire, and a bed of earth and water, of nearly the same length as the wire. One of the plates remained in the well, the other was plunged in the sea. In a second experiment that I made immediately afterwards, both plates were plunged in the sea. In both cases I still continued to obtain 8°. The battery current never changed its intensity: I cannot, therefore, recur to currents derived from the terrestrial currents, in order to explain the fact. Paying due regard to the nature of the soil of Pisa, which is for the most part formed of a stratum of alluvium very recently deposited, and in which water is found at a few feet beneath the surface, I was desirous of making an experiment in a different soil. For this purpose, I betook myself to the hills of Crespina, which are sixteen miles from Pisa. In the wells that I employed, the water is 30 or 40 *bras* (57 or 76 ft.) beneath the surface. I operated at two different stations, always keeping the same length of wire extended, which, in this case, was 4260 *bras* (8094 ft.) The distance between the two wells, in the first experiment, was 3500 *bras* (6650 ft.) In the second experiment, the distance between the two wells was one mile, namely 2800 *bras* (5320 ft.) The battery current, without the additional circuit, was still 17°. In the first experiment, the circuit was composed of 2470 *bras* (4693 ft.) of wire, and the earth between the two wells 3500 *bras* apart. In the second experiment, the circuit consisted of the same wire, and 2800 *bras* of earth. I obtained in both cases the same deviation, which was 8°·5.

Digitized by Google

The experiments were made with the same care, and confirm the facts observed when operating on the soil of Pisa. I may add that, on operating with one of the plates in the well, and with the other soldered to the wire and lying on the ground, I obtained, under the same circumstances, sometimes 3°, at other times 4° and 5°, according as the plates rested on sand, on moist sand, or on the turf. Instead of the battery and the iron plates, I attached a zinc plate to one end of the wire, and a copper plate to the other. Each of these plates presented half a square metre (·598 sq. yd.) of surface. When the wire was 4885 *bras* long, there was a constant current of 4°.

I confess that I was desirous to have had the opportunity of operating on greater lengths; and with this object in view, I send this memoir to the president of the approaching congress at Milan, to induce him to have these experiments attempted on a large scale, with a portion of the funds that the city of Milan has placed at his disposal for experiments. The results which have presented themselves, from the experiments that I have related, induce me to conclude that the resistance of the earth for the electric current is nothing in great distances. Mr. Bain in England, and especially M. Jacobi at St. Petersburgh, had already found that this resistance of the soil might be regarded as exercising no influence. But I believe that my experiments have proved this result in a more direct and decisive manner. I must again conclude that, when a current is transmitted by a circuit composed in parts of a long copper wire and of a long bed of earth, the diminution suffered by this current from the resistance of this mixed circuit is less than that which it would have suffered by the resistance of the copper wire alone. This conclusion, which ought to be demonstrated by operating on a larger scale, still remains to be explained. I shall conclude by saying that my results may lead to an application important to telegraphy. Whatever be the wire and its insulation, the earth may always be employed to form the half of the circuit; and in this manner all the expenses and difficulties will be reduced one-half.* [A.]

* We need scarcely remind our readers that this application has been made for many years.—Vide *Elec. Mag.* p. 64.

Digitized by Google

XCIV. *On the Experiments of the Transmission of Electric Currents executed at Milan, during the Meeting of the last Scientific Congress.* Note extracted by M. MATTEUCCI from his correspondence with M. BELLI. "Comptes Rendus," Oct. 21st, 1844, vol. xix. No. 17, p. 845.

(TRANSLATION.)

PROF. BELLI has communicated to me the results of the experiment made upon my proposition,* on the conductibility of the earth by the electric current. The two stations were Milan and Monza.

In the first experiment, the circuit, entirely metallic, was nearly 12,500 mètres, (7¾ miles). In the second, the circuit was partly metallic, namely, 12,500 mètres of wire, and 12,500 mètres of earth. In the third, the circuit was entirely metallic, 25,000 mètres (15½ miles).

The pile was a single constant pair.

The intensities were in the ratios 30 : 27 : 17.

From this would result the confirmation of what I had found at less distances.

The first circuit, entirely metallic, which gives 30, is half the second in length. The second is composed of the same wire and of the earth, and in this case is 27. The difference, which is very small in comparison to the double length of the circuit, would undoubtedly have been found at less distances of earth; for it is due to the changing of the conductor.

In the third experiment, when the circuit is all metallic, and of the same length as the second, the difference becomes very great.

When the earth is employed at great distances, not only does the distance due to the length disappear, but we do not even find that which is due to the wires employed. I doubt whether this result is due to chemical actions on the plates. It would be very important to science and to telegraphy to make more extensive experiments.—[A.]

XCV.—*Experiments on Telluric Electro-Motive Force, executed by* M. MANGRINI, *with the Apparatus that the city of Milan caused to be constructed, on the occasion of the Sixteenth Scientific Congress.* From "Comptes Rendus," Jan. 20, 1845, vol. xx., No. 3, p. 183.

(EXTRACTS.)

"THIS note is extracted from a long and circumstantial

* Vide *Elec. Mag.* present No., p. 592.

Digitized by Google

work already discussed in the sittings of the 15th, 25th, and 27th of September, 1844, of the 16th Scientific Congress, and in those of the 5th and 21st of December of the Imperial Institute of Lombardy.

"Along the railway that leads from Milan to Monza, four wires were extended to a distance of 13 kilometres (8 miles),—two of these wires were of iron, of the diameter of 1·2 mm., (·047 in.), and the other two of copper, of the diameter of $\frac{5}{6}$ mm. (·0246 in.) So that the sections of the two metals were in inverse proportion to their conductibility. These wires, which together afforded a circuit of 52·km. (32 miles), were supported by stakes of dry wood, to which were attached iron pegs, covered with varnished silk. The wires were secured by a single turn round these pegs.

"After many experiments, executed with very great care,—experiments described in my work that is soon to be published,—it was recognised that the insulation of the wire might be regarded as physically perfect, so long as they were traversed by currents of feeble intensity, such as are the telluric currents and those produced by a Bagration pile, which I generally used.

"The following are some of the principal results obtained:—

The author here mentions certain phenomena which presented themselves in the wire *before* the circuit was completed; but as they are evidently the results of defective insulation, it is not necessary that we should detail them here. We give, however, in the sequel (20 and 33), our author's deduction, which may serve as an illustration of the phenomena in question.

"8. A metal wire supported in the atmosphere, terminating at its two extremities by two plates buried in the earth, constitutes a rheomotor, in which two currents are produced,—that is to say, there is in the wire a compound movement. The two currents are contrary or conspiring, according as the plates are formed of metals, capable of exciting the electric fluid in the same, or in an opposite direction—namely, they are contrary when the two currents ascend, or when the two descend by the wire, and they are conspiring when one ascends and the other descends. In the first case, we obtain a resultant almost equal to the difference of the elementary actions, (the electro-negative pole being always on the side of the prevailing action); and in the second case the resultant approaches the sum of the same actions.

"9. Although the plates may be formed of the same metal, and may have their surfaces of equal size, and be perfectly

Digitized by Google

cleaned, the cessation of equilibrium always occurs in the wire. The current that is manifested in such a case as this, is not due to the absolute want of homogeneity in the plates, but depends rather on the quality of the earth or of the water in which they are plunged (at least according to the experiments hitherto executed); for the current still preserves the same direction, when the two plates change places of immersion."

(The author now mentions a few properties of telluric currents in traversing the so-thought closed circuits, and the *nodes* or places of maximum intensity.)

"*On the cause of telluric currents.*

"20. In the present state of science, it does not appear that these phenomena can be explained without attributing to the terrestrial globe an electro-motive force capable also of destroying that which is commonly produced between metals and isolated liquids. Our planet-world becomes the most negative electro-motor of all the metals hitherto named, excepting zinc, because it would drive the fluid into the former, and would receive it from the latter."

(The author then alludes to M. Becquerel's illustrations of the development of electricity by the mere immersion of a metal in a liquid; to which liquid he compares the earth and its contained fluids; and on which relation alone does he feel able to explain the otherwise anomalous phenomena.)

"*The earth conducts electric currents.*

"The experiments made on this subject by M. Matteucci,* lead to complex results, which belong to this new order of phenomena.

"23. I have found that a portion of earth interposed between two metal plates, joined together by means of conducting wires with the poles of a voltaic pile, opposes to the passage of the current a resistance which may be equal to, or greater or less than, that presented by a very fine metal wire having the same length, according to the nature and size of the plate.

"In such researches we must take care to bear in mind the electro-motive power of the earth, and the telluric currents, which may either oppose or concur with the voltaic current, and we must consequently have regard to the correction which these conflicts require.

"24. In general the resistance of the earth diminishes to a certain limit, by increasing the surface of the plates that are plunged in it.

"25. It hence follows that in a mixed circuit, namely, in

* *Vide* Elec. Mag., p. 587.

Digitized by Google

one formed partly by the metallic wire and partly by the earth, the current may acquire more efficacy than in a circuit all metallic of the same length.

"This fact has already been put forth by M. Matteucci.

"26. We have not, however, found that, with the intervention of the earth, the resistance opposed by the metal wire, which makes part of the circuit, may diminish, as M. Matteucci seems to have deduced from his first experiments.

"27. In like manner, we have not found that an interval of earth, of greater or less length, presents the same resistance, as seemed to be the case to the experimenter of Pisa.

"With regard to myself, I have demonstrated, by a long series of experiments variously combined, that, when the earth intervenes in a voltaic circuit, it comports itself like ordinary conductors; and that to the earth, as well as to every other conductor, may be applied the law, which M. Ohm included in his formula.

"For example, I have found that the earth, beside my apparatus, presents a resisting *medium* equivalent to that of 260 metres (284 yds.) of my wire, for each kilom. (6213 miles) of distance; and that the *resistance to passage*, which may be considered as a constant, corresponds nearly to 200 metres (218 yds.) of the same wire.

"Prof. Matteucci was not able to detect this resistance, because he operated between very short distances (a few hundreds of metres), and with a galvanometer that was not very sensible."

(The author here mentions certain properties of the currents, when they traverse circuits composed of various metals.)

"*Facts, which still further tend to connect the physical theory of electricity with the principle of vibrations.*

"In order to conceive the phenomena, of which we have made mention, how the rupture of electric equilibrium is brought about, and how a current is engendered, I have thought it necessary to revive again the idea of waves, because, in the present state of our knowledge, we are permitted to think that the system of vibrations may also rule over the physical theory of electricity, and lead, at least partially, to the same principles as for the theory of light and radiant heat.

"32. By placing three shortish wires so as to conduct, at the same time, two unequal voltaic currents, independent of each other, and of constant force, to two separate galvanometers, the latter mark simultaneously with the usual index the same deviations as are manifested when the circuits are closed separately. And, in this case, the same conductor (the

Digitized by Google

intermediate or central wire) being in contact with the copper pole of one rheomotor, and at the same time with the zinc pole of another rheomotor, must give passage, namely, must serve as a vehicle to two simultaneous currents, unequal and contrary, without a sensible alteration; or it must be endowed with some property, which may correspond to this office.

"33. If the copper pole of a voltaic pair (constant and isolated) be joined with a very long metal wire, which on one side is extended into the atmosphere without communication with the soil; and if the zinc pole of the same pair is joined with another wire extending equally on the other side, there are manifested in the two wires two vigorous currents of a constant character, and in a direction contrary to each other, although the circuit is not closed, nor any part of the system is found in direct communication with the earth, and although there is not any metallic contact between the two plates that constitute the poles of the rheomotor. Along the wires, the intensity of these currents varies with the distance of the poles."

In the work which the author has in hand, he promises to show the application of these currents to the arts of life; in the mean time, we give the above extracts as supplementary to the papers, by MM. Becquérel and Matteucci. The theoretical views are obviously wrong somewhere; but these we shall not at present discuss: we are more anxious to present the facts to our readers, that they may themselves know how the earth comports itself under the circumstance assigned; the time cannot be far distant when the confusion in which these phenomena are involved may be removed, and the true connection of the facts with each other may be established.—EDITOR.

XCVI. *Memoir in completion of the Work relating to the Concentration of Magnetic Force on the Surface of Magnets, presented in May,** 1844. By M. DE HALDAT. (Extract by the Author.) From "Les Comptes Rendus." Jan. 6, 1845, vol. xx., No. 1, p. 20.

(TRANSLATION.)

MY memoir upon the concentration of magnetic force toward the surface of magnets, the analysis of which appeared in the

* *Vide* Elec. Mag. No. 5, p. 353.

Digitized by Google

Comptes Rendus des Séances de l'Académie, t. xviii., p. 843, Sitting of May 6th, 1844, having excited certain objections, in respect to the expression which I employed for characterizing the fact—in announcing that this concentration takes place *towards* the surface of magnets, and not *at* the surface, like that of the electric fluid at the surface of conductors; I have endeavoured to characterize this concentration with greater precision, by devoting myself to new researches. The means that I first employed consisted in diminishing successively the thickness of the iron tube employed, until I attained to a thin leaf of sheet-iron. In other respects, I retained the tube of the same length; I made but little diminution in its surface, but I varied the mass to a very considerable extent by the addition or withdrawal of the cylindrical nucleus that formed part of the apparatus. I thus confirmed the conclusions of my first memoir; I proved the little influence of mass over the development of the magnetic force; and hence its concentration in the molecular strata which form the surface of magnets. It was principally characterized by the power of the iron tube employed, which, first weighing 280 grammes, then 160, then 90, gave the needle by which this power was measured a force whose intensity, as indicated by the number of oscillations in a given time, only varied a single oscillation out of 15, 16, or 17.

The magnet being thus brought to so feeble a thickness, leaving no further means of proving more completely, by the same process, the concentration in the molecules composing the surface, I endeavoured to render it sensible in metal plates, the solidity of which being excessively small in relation to their surface furnished a new argument in favour of concentration. The instrument invented by M. Arago for executing the experiments of magnetism by rotation furnished me with the means: leaves, to wit, of gold, silver, copper, or tin-foil, being fixed on small discs of card, and suspended by filaments of the cocoon over a rotating magnet, experienced its influence, and were drawn along in the same manner as thicker discs.

This mode of experiment, which might necessarily seem to be confined to the ductile metals, was applied with the same success to the brittle metals, which, when reduced to powder, and fixed in the same manner, acquired—as did the powder of iron—magnetic force, and furnished a new argument in favour of my opinion on the universality of magnetism; namely, on the disposition of all bodies to acquire magnetic force. By the same process, I endeavoured to appreciate one of the most efficacious causes of the alteration of magnetic

Digitized by Google

force, by subjecting to this mode of investigation the compounds of iron with bodies that are recognised as the most powerful in altering the disposition of this metal to acquire magnetic force—so as to appreciate approximately the influence of the proportions in the compounds; and, finally, that of the affinity that presides over these combinations.—[A.]

These experiments do not appear to us at all to the point: when discs, such as Dr. De Haldat describes, are found to follow a magnet rotating above or beneath them, it is in virtue of electric currents generated to them by the moving magnet, as was demonstrated long ago by Faraday. All, therefore, that we can gather from them is, that *thin* discs equally with thicker are susceptible of evincing the magneto-electric current. We can scarcely regard these discs as true and proper magnets.—*Ed. Elec. Mag.*

SCIENTIFIC MEETINGS.

ROYAL INSTITUTION.

Feb. 7, 1845.—Prof. Grove "On the Voltaic Arc."—Mr. Grove introduced the subject, by briefly reverting to views, which he had elsewhere set forth,* relative to the correlation of forces, and their mutual convertibility into each other. He gave his opinion that, humanly speaking, force like matter is never annihilated, though frequently diffused among material things until it is so dissipated as to be imperceptible to our senses; and that when motion is apparently arrested, as in the case of two balls impinging on each other, the motion as such is lost; but a new force is called into existence at the point of impact, to wit,—*Heat*, which may, as he thinks, be indeed but a subdued motion, —which, at all events, is a mode of force, and is capable of reproducing motion. He gave an experimental illustration of this conversion of motion into heat. By like reasoning, he showed the source of the electric spark, and other electric phenomena, to be the motion imparted to the glass of the machine by the hand. Coming now to the subject for the evening, he pointed out the peculiarities of the electric spark, according as it passes between this or that metal; he took for his illustration, the bluish light from tin, the greenish from silver, and the scintillations from iron, he showed that these were equally the characteristics of the above metals when used for terminals to the voltaic arc; and he added that they were, in like manner, the characteristics of the same

* Vide *Elec. Mag.* No. 3, p. 220.

Digitized by Google

metals, when undergoing ordinary combustion. The natural consequence of this is, that the light of the arc is due to the incandescence of solid particles passing from electrode to electrode. The bright white arc between charcoal points is a further illustration of this proposition, white being the characteristics of incandescent carbon. The light observed in all these cases is not to be regarded as a phenomenon of ordinary combustion, for the incandescent bodies are not necessarily burned; they are not necessarily thrown into a state of union with the oxygen of the atmosphere, but are, for the most part, volatilized by the intense heat to which they are subjected. He illustrated the volatilization of metals, when in an unoxidating medium, by taking the arc between iron electrodes within a closed bell-glass of nitrogen:—after a few minutes the deposit, which had been condensed on the inner surface of the glass, was washed off with dilute acid; and on being tested by ferro-cyanide of potassium, it gave the usual indications of the presence of iron.

In illustration of a conversion of the light into chemical action, he made two circuits for the current; one included the voltaic arc, the other a voltameter. While the voltameter was charged with distilled water, which is scarcely decomposed by the current, the arc retained its primitive brilliancy; but in proportion as the water was rendered conducteous, and consequently decomposable, by the addition of sulphuric acid, more and more of the force travelled by that circuit, and the arc was diminished to a small spark.

He now adverted to Mr. Gassiot's experiment,* in which it had been found that, of the two metal terminals, between which the arc was obtained, the positive became more highly heated than the negative during the existence of the arc in air; he repeated the experiments, under several forms, with success. For instance, he employed a copper positive terminal and a zinc negative one; and although the latter was thus constructed of a metal so much more fusible than the other, yet it preserved its integrity, while the former melted off in drops. He traced this phenomenon to the essential characteristic of a positive electrode to combine with oxygen for the production of chemical action and heat; and could see no difficulty in assigning the rise of temperature to this property. To the same source he traced the apparently anomalous fact of the negative electrode producing more flame when within an acid solution than does the positive; he considered that the solution intervening between the two electrodes is to be regarded as a continuation of the positive electrode, and that the actual terminals are in the place where the solution, coming into contact with the negative electrode, is boiled,—and where the arc passes across the intervening film of vapour,—it is there that the sulphur, and such other matters contained in the compound, are eliminated and burned, and thus is the light produced. He gave a few

* Trans. Elec. Soc. p. 69.

Digitized by Google

experiments illustrative of the assistance given to the current, by interposing in the positive order an oxidizable metal; and concluded by explaining a few of the difficulties which had assailed him in many of his investigations in respect to the arc; and by pointing out the promising character of these researches, if patiently followed out. Among the practical applications of the arc, he mentions the making of alloys of the refractory metals, by dropping them into those of easier fusion, and showed a button of an alloy of platinum and copper formed by these means.

LONDON INSTITUTION.

Jan. 8, 1845.—Prof. Grove communicated to the proprietors at this their first *soirée* for the season, some of the leading discoveries in physical science during the past year. Of electrical subjects, M. Matteucci's researches* were described, with experimental illustrations; as also the magnetic note.† In reference to the latter, Mr. Grove detailed a curious experiment that had occurred to him, and which bore greatly on the subject. A glass tube open at the ends, but protected along its length with a copper jacket, was filled with water, in which was suspended powdered magnetic oxide of iron. On looking through the tube at distant objects a considerable portion of the light was intercepted by the heterogeneous arrangement of the particles of the oxide; but, on passing a current through a coil placed round the tube, these particles assumed a symmetrical character, and much more light was transmitted. This experiment was alluded to as an illustration of the molecular polarization and vibration that is attributed to the particles of an iron rod, when a musical note is obtained under the influence of the current.

CHEMICAL SOCIETY.

Jan. 6, 1845.—A paper was read of "Observations on the Decomposition of Metallic Salts by an Electric Current," by Mr. James Napier. His observations bore reference to what is regarded as

"A fundamental law in electro-decomposition, that the amount of any element or salt radicle liberated at one electrode is an exact equivalent of another element or salt radicle liberated at the opposite electrode."

But,

"There is no law which appears to him more definite than that, if a large positive and small negative electrode be used, there will be more dissolved from the former than is deposited upon the latter; or, on the contrary, if a large negative and small positive electrode be used, more will be deposited upon the negative than is dissolved from the positive."

These facts have presented themselves to him during his daily experience in Messrs. Elkington's manufactory: he has not, however, depended on mere generalities, but by accurate appeal to the balance, has shown, beyond doubt, that such is the case. The conclusions to which he arrives are,

* Vide *Elect. Mag.* No. 7, *passim.* † Ibid. p. 527.

Digitized by Google

"That the element liberated at the negative electrode is a proper measure of the amount of electricity, passing through the electrolyte, if that electrolyte be composed of one equivalent of base, and one of acid, or of single equivalents of elements; and if a sub-salt be the electrolyte, there will be two proportions liberated at the negative for one proportion of zinc destroyed in the battery; and if a tri-sub-salt be used, three equivalents will be deposited, &c., all electrolytes being decomposed as if they were constituted of two elements."

"It may be remarked in the second place, from these results, that the stronger the solution of cyanide of potassium is, there is comparatively more dissolved from the positive electrode; that this may arise from the metals used as electrodes being very soluble in that menstruum, and that the difference between the electrodes is simply the result of this solubility: that it is the result of solubility rather than direct electrolysis the experiments detailed fully show."

He also adds,

"Whether this increased tendency in the metals to dissolve, when made the positive electrode, be an exalted affinity excited between the metal and the negative element of the electrolyte, we will not as yet venture to assert, although the facts bear evidence to this."

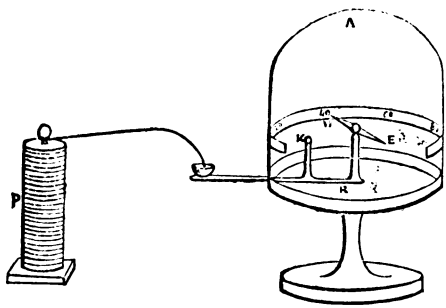
NEW BOOKS.

Magnetic and Meteorological Observations, made at the Royal Observatory, Greenwich, in the year 1842, *under the direction of Mr. Biddel Airy, Astronomer Royal. London, Murray,* 1844, *4to. Two guineas and a half.—Magnetic and Meteorological Observations at Prague, from August* 1842, *to 3rd December* 1843. *M. Kreil,* 1 *vol. 4to.—Treatise on the Forces which produce the Organization of Plants, with an Appendix, containing several Memoirs on Capillary Attraction, Electricity, &c. Prof. John Draper, M.D., of New York, 4to. plates,* 18*s. Wiley and Putnam.—Detection of Needles and other Steel Instruments in the Human Body, by Alfred Smee, F.R.S., Pamphlet,* 6*d. Renshaw,* 1845. — *Histoire Scientifique et Artistique de l'Electro-Metallurgie, art originairement Italien; par M. le Prof. G. Grimelli. Modena,* 1844, 8*vo.—Elective Polarity, a universal agent. Frances Barbara Burton. Simpkin, London,* 1845, 8*vo.* 7*s., pp.* 171.— *Observazioni ed Esperienze sall Elettricita, Dr. Elice, Genoa,* 8*vo. pp.* 16.—*Trattato del Magnetismo e della Elettricita, F. Zantedeschi, Parte I. Modena,* 1844, 8*vo. pp.* 389, *plates.—Della Trasporto della Materia Pesante nelle due opposte correnti, &c. F. Zantedeschi. Venice,* 1844, 4*to. pp.* 11.—*Memoria sul-Termo Elettricismo Dinamico nei circuiti formati di un solo metallo. F. Zantedeschi, Venice,* 1844, 4*to. pp.* 15, *plate.*

Digitized by Google

NOTICES OF EXPERIMENTS, &c.

M. Rousseau's *Diagometer.*—"About fifteen years ago, M. Rousseau proposed another method for recognising the purity of olive oil; it is founded on the property possessed by olive oil of not conducting electricity, except with great difficulty, whilst other vegetable oils transmit it easily. This method requires the employment of a special apparatus, which he has designated by the name of *diagometer*, and of which we will here describe the principal parts.



"A is a bell-glass, resting on a moveable resinous plate R; in the centre of this plate is fixed a very fine metal stem, supporting a needle E W, which is feebly magnetized, and carries at one of its extremities a small disc of tinsel. A horizontal metal rod connects the support of the needle with a small metal capsule containing the oil that is to be examined; on the length of this horizontal rod rises a second stem K, which terminates at the height of the needle by another tinsel disc; finally, a small dry galvanic pile P,—constructed of little circles of zinc and copper, between which are placed circles of paper, oiled with poppy oil,—is placed vertically at a little distance. It is placed in communication with the little capsule by means of a platinum wire.

"In order to experiment by aid of this apparatus, the moveable plate of resin is turned round until the little disc, carried by the magnetized needle (which latter is in the magnetic meridian), touches the disc of the vertical stem K. Some oil is then placed in the capsule, and communication is made with the pile. When pure olive oil is used, no motion is perceived in the needle; but if it is mixed with poppy oil, or any other seed oil, the needle is immediately deflected by the passage of the electricity, which produces a repulsion between the two discs, and keeps them at a certain distance from each other.

"The conductibility of the oil is measured by the arc of the circle traversed on the circumference of the ball-glass; and by the time which the needle requires in order to attain a higher degree of deviation. The less the oil conducts the electricity, the slower is the deviation. According to M. Rousseau's experiments, olive oil conducts electricity 675 times less readily than does every other vegetable oil. With the apparatus that we have described, we can recognise a hundredth part of foreign oil added to olive oil."

Digitized by Google

—"*Falsifications des Substances Alimentaires,*" p. 419. MM. Jules Garnier and Ch. Harel.

Electric Telegraphs.—Wheatstone's and Cooke's telegraphs have been recently completed on the South Western Railway, between Portsmouth and London (Nine-Elms), a distance of 88 miles. Their working is very satisfactory; the Queen's speech on the opening of parliament was conveyed to Portsmouth by telegraph and immediately printed. It is very remarkable to find how the laws of resistance are carried out in this great length, wherein one part of the circuit consists of many miles of mere earth. The French government are adopting the same telegraphs on their lines of railway.—Ed.

Electro-cultural Society.—A project is on foot to establish a society with the above title, with a view of seeing how far electricity may be made available in bringing about an increase of product. The idea originated from an experiment by Mr. Forster, of Findrassie, near Elgin, on a plantation of oats.—Ed.

Muscular Current from Human Muscle.—"The experiment on the muscular current of man was last week performed here [Pisa] by one of my pupils; and he was very successful."—Extract of letter from Prof. Matteucci to C. V. W., dated Dec. 30, 1844.

Faraday, Foreign Associate of the French Academy.—"The Academy proceeds by ballot to the nomination of a foreign associate in place of the late Dr. Dalton. At the first balloting, the number of voters being 55,

Faraday obtained	34	votes.	
Jacobi	,,	19	,,
Buckland	,,	1	,,
Melloni	,,	1	,,

Mr. Faraday having obtained a complete majority of votes, was proclaimed elected. His nomination will be submitted to the approbation of the king."—*Comptes Rendus*, Dec. 23, 1844.

"The Minister of Public Instruction transmits the duplicate of the Royal Ordinance, which confirms the nomination of Mr. Faraday to the place of Foreign Associate, vacant by the decease of Dr. Dalton."—*Ibid.*, Jan. 20, 1845. Our readers will join with us in congratulating our illustrious countryman at this the highest honour that the French Academy could confer.

Electric Telegraph furthering the ends of Justice.—The following communications were sent by the needle telegraph between Slough and Paddington, on the first day of the present year.

Message.

A murder has just been committed at Salt Hill, and the suspected murderer was seen to take a first class ticket for London by the train which left Slough at 7h. 42m. p.m. He is in the garb of a Quaker, with a brown great coat on, which reaches nearly down to his feet; he is in the last compartment of the second first-class carriage.

This message having reached Paddington before the train came

Digitized by Google

in, proper arrangements were made, and the result was telegraphed back in the following words :—

The Reply.

The up-train has arrived; and a person, answering in every respect the description given by telegraph, came out of the compartment mentioned. I pointed the man out to Sergeant Williams. The man got into a New Road omnibus, and Sergeant Williams into the same.

The reporter for *The Times* remarks, "had it not been for the efficient aid of the electric telegraph, both at Slough and Paddington, the greatest difficulty as well as delay would have occurred in the apprehension of the party now in custody."

Elasticity of Metals influenced by Electricity.—A series of experiments by M. Wertheim lead to the following conclusions:—1st. "The galvanic current produces a momentary diminution in the co-efficient of elasticity in the metal wires, which it traverses; and this takes place by its proper action, and independently of the diminution arising from elevation of temperature. This diminution entirely disappears with the current itself, however long the duration of its action may have been. 2nd. The extent of this diminution depends on the force of the current; and probably also on the resistance opposed by the metal to its passage. 3rd. The cohesion of wires is diminished by the current; however, the variation in this property does not permit of our distinguishing whether this diminution is due to a proper action of the current, or rather whether it arises solely from elevation of temperature. 4th. Magnetisation both austral and boreal, excited by the prolonged passage of the current, produces a slight diminution in the co-efficient of elasticity both in soft iron and in steel. This diminution remains in part, even after the interruption of the current."—*Comptes Rendus*, July 22, 1844, Vol. xix. No. 4. p. 231.

Constant Pile.—M. Desbordeaux states that a Wollaston's pile may be converted into a constant pile "that works with the same intensity for several days consecutively," by charging it with a concentrated solution of sulphate of zinc, to which a little sulphate of copper and sulphuric acid have been added; and that, when its action begins to fall, it may be restored by adding a little more sulphate and sulphuric acid.—*Comptes Rendus*, July 30, 1844, Vol. xix. No. 5, p. 273.

Reduction of M. Freycinet's Magnetic Observations.—The death of M. Freycinet having occurred, while his observations, made during the voyage of the brig *Uranie*, were unreduced, M. Duperrey undertook their reduction, and has given the results in the *Comptes Rendus* for Sept. 2, 1844. The observations themselves were given in M. Freycinet's *Magnétisme Terrestre*, published in 1842.

Durertype—is a term applied by Mr. Dircks to a process for copying prints, &c. The word is derived from Albert *Durer*. A flat glass is placed on the print, and covered with a thin stratum of

Digitized by Google

white wax, so thin that the print can be seen through it. The wax is then cut through with ivory needles. The etching thus made is subjected to the electrotype process; and the cast obtained, when mounted on wood is printed from, with the type, as an ordinary wood block.—*Athenæum*, Jan. 11, 1845.

Buried Plates.—"The physiological effects of my subterranean arrangement* have very greatly increased,—the shock is now perfectly intolerable. I have not examined the state of the plates, or indeed meddled with them since they were buried, now about a year ago. Their action in depositing electrotypes is very steady and satisfactory."—*Rev. F. Lockey to the Editor*, Jan. 28, 1845.

Needles in the Human Frame detected by Electricity.—Mr. Smee proposes to apply an electro-magnetic coil in juxtaposition to the suspected place; and on magnetising the needle by the presence of the current, a compass-needle will indicate its position.

Neutralization of Local Attraction.—A patent by Mr. W. Bush was enrolled, May 9, 1844, for improvements in rendering magnetic needles less prejudicially influenced by local attraction: his claim is for "causing the attraction arising from local causes to be centralised in or near the axis of motion of magnetic needles;" for "constructing magnetic needles with three or more points;" and for "the floating of an axis for a magnetic needle by means of a fluid."—The specification and drawings may be found in the *Repertory of Patent Inventions*, for July, 1844, at p. 31.

Electric Clocks.—"Mr. Bain has succeeded to admiration in working electric clocks by the currents of the earth. On the 28th of August he set up a clock in my drawing-room, the pendulum† of which is in the hall, and both instruments in a voltaic circuit, as follows:—On the north-east side of my house, two zinc plates, a foot square, are sunk in a hole, and suspended to a wire; this is passed through the house, to the pendulum first, and then the clock. On the south-east side of the house, at a distance of about forty yards, a hole was dug 4 feet deep, and two sacks of common coke buried in it; among the coke another wire was secured, and passed in at the drawing-room window, and joined to the former wire at the clock. The ball of the pendulum weighs nine pounds; but it was moved energetically, and has ever since continued to do so with the self-same energy. There are but three little wheels in the clock, and neither weights nor spring; so there is nothing to be wound up."—Mr. Finlaison, *Polytechnic Review*.

Electro-Telegraphy.—The Rev. H. Heighton's patent‡ was dated September 16, 1844; specification enrolled January 18, 1845. The inventor uses Leyden batteries charged with the hydro-electric, or other powerful machine; he regulates the number, nature, and times of the discharge by an instrument, modified according to circumstances, and states, that in ten discharges any signal out of 16,000 may be made; in thirty any signal out of

* Vide *Elec. Mag.* No. 4, p. 279; No. 5, p. 393. † Ibid. p. 116.
‡ Ibid. p. 472, where we miscalled him W. Highton.

Digitized by Google

1,000,000,000. "The method of reading the signals at the terminal point is by means of two wires, one communicating with the point of transmission and the other with the earth; they are placed at right angles to a sheet of paper, which is moved along by machinery, so that each discharge may traverse the surface, and penetrate the substance of the paper close to the wire giving out the negative fluid. The paper is covered with chromate of lead, and moistened with sulphuric acid to expedite the passage of the sparks, and by this means the sparks leave upon the paper a register of the signals that have been made."—*Mech. Mag.*, Feb. 22, 1845.

*Galvanic Rings.**—The fever for these articles has raged violently since our last. At the outset they "fetched a good price," and were only to be met with here and there; now we find them thrust almost on to our very fingers at the corner of every street, and can obtain them in exchange for our pence. Enter a coffee-room, two or three out of every half dozen of those present glory in these absurd circlets; enter an omnibus, your next neighbour will remove his glove and disclose to your view two or three of these hideous decorations; we are completely haunted with galvanic rings. The columns of our newspapers teem with advertisements of the "Real Galvanic Rings," the "Genuine Galvanic Rings," "Beware of Counterfeits," &c. &c. Placards and hand-bills beset us in every thoroughfare. In reading these the difficulty is not to discover what they will cure, but what they will not. If this panic does not soon subside, "Parr's Life Pills," and Morison's Universal Panacea, will be at a discount. The vendors now are not content with offering for sale a plain ring, such as was described in our last, but they get them up in gold, with zinc and *copper* let in on the inner side; by-the-by, they might as well leave the copper out. Cinctures of all sizes are offered to the afflicted for their ears, their feet, their bodies, their heads, and so on; and of course every now and then we hear of marvellous cures. To be serious, we are ashamed to see tradesmen, who should know better, succumb to this popular mania; it does not speak much for the intelligence of our "nation of shopkeepers," unless as shopkeepers.—*Editor.*

Polarization of Electrodes.—"In the experiments which I made in 1806-7, in company with Mr. Thesinger, we had found that rods of metal which were employed to decompose water by means of the galvanic pile, continued to develope gas after their connection with the pile had ceased, a circumstance which seemed to indicate a continuance of electrical state, though the rods showed no action upon any other portion of liquid even of the same kind, than that in which they had been placed during their contact with the pile. This observation, which I had almost forgotten, has been lately confirmed by Pfaff, who has also added to it several others of a similar kind. We might suppose such effects to be produced by a residual polarity, both in the liquid and the metal, showing

* Vide *Elec. Mag.* p. 551.

Digitized by Google

itself as long as it continues by a continuation of chemical action, but some of Pfaff's experiments seem to oppose this idea, for he found that the addition of ammonia to the liquid, by which all its internal polarity was destroyed, did not deprive the wires of their effect. The metals which acquire this property in the highest degree are iron and zinc, next to which is gold. He attempts to explain the phenomenon, by supposing that the continued passage of the electrical stream had brought the elements of the water nearer to a state of separation, so that a very slight influence was sufficient to destroy their union. It must be confessed, however, that at present we cannot advance a satisfactory explanation."—*Berzelius Arsbesattelse*, 1829, page 33.—From Journal of the Royal Institution. Oct. 1830, p. 167.

Odd Influences attributed to Electro-Magnetism.—A certain Dr. Sommé supposes that external objects reach the brain, and put in action the organs of the senses, by means of the electro-magnetic agent. The following are among his illustrations:—As it is not possible that the sight of pigeons, let loose three hundred leagues from their home, can avail in guiding them back, he supposes that a magnetic current directs them, serving as a compass, through some unknown relation between the animal and the place of its abode.—When the vine is in flower, the wine that has been made from the said vine is stated to be disturbed by a similar sympathetic relation, although five or six hundred leagues distant.—An inhabitant of Bruxelles, having lost his nose in a fight, desired to have it renewed; but not having courage to part with skin for the purpose from his own arm, he paid a labourer to allow the nose to be made from his arm. So far all was well, and the nose was obtained. But about thirteen months afterwards, the nose suddenly, and without any apparent cause, became torpid, and in a few days mortified. On inquiry, it was found that, at the very moment when the nose became torpid, the labourer died.*—A young lady, in her fits of hysterical somnambulism, had a habit of throwing a pillow at her housekeeper's head; and whether the old lady were in view or not, "the pillow always followed the shortest direction between these two persons." The doctor, thinking there were magnetic relations between the two, took the housekeeper's hand, and during such contact the manœuvres of the somnambulist ceased. Another somnambulist enjoyed "sight by the region of the stomach, when covered with her ordinary garments;" and was thus enabled to play at cards. "The idea occurred to me," says the doctor, "of covering this part with a silk handkerchief, arranged as an apron: she then ceased to see her cards. When she had succeeded in removing the handkerchief, so as to uncover the stomach, she continued her game. From these two facts," he says, "it is rational to conclude, that there is a magnetic relation between exterior bodies and the organs of the senses."—*Bull. Roy. Acad.*, Brussels, Aug. 5, 1843.

Wagner's Electro-Magnetic Machine.—We hear that the Com-

* *Vide* HUDIBRAS, Part I., Cant. 1, l. 281.

Digitized by Google

missioners appointed by the Diet to examine M. Wagner's electro-magnetic machine, have proposed to the Diet to grant him an indemnity (6000 florins, it is said) for his expenses and labour, but that the Diet has refused. Every body expected this result of the affair.—*Dutch Papers*, July 8th, 1844.

Law of Magnetic Disturbance.—M. Lamont, of Munich, by comparing magnetic disturbances in divers places, has been led to "announce, as a general proposition, *that in every magnetic disturbance there is a constant relation between the amplitude of the oscillations observed in different places in Europe.*"—*Bull. Roy. Acad.*, Brussels, Aug. 5, 1844.

Effect of a Storm on a Galvanometer.—During a storm at Brussels, on the 7th of July, at half-past eleven, P.M., the needle of a delicate galvanometer, by Gourjon, attained a permanent deflection of 24°; one of its wires being connected with the earth, and the other with a metal point on the roof of the observatory. The fact is described by M. Quetelet as being remarkable.—*Bull. R. Acad.*, Brussels, July 8, 1843. In the account of Kew Observatory, we read:—"A galvanometer, by Gourjon, has been added to the instruments by Prof. Wheatstone, and promises to become the nucleus of a very valuable assemblage of new facts; it has not been successfully applied in low intensities; but with high tensions the needle has been strongly affected."—*Kæmtz's Meteorology*, p. 554: Walker's Translation.

Electròdes and Eléctrodes.—"The term *electrode*, which has been Latinized *electrodus*, was proposed by Faraday as a substitute for the word *pole*. It is derived from the Greek words ἤλεκτρον and ὁδος, *a way*. The term is objectionable on the ground of its prior use in another sense. Hippocrates (p. 1135, ed. Fræs.) uses the word ἠλεκτρώδης from ηλεκτρον, *amber*, and εἶδος (*external appearance*), in the sense of *amber-like*, in reference to the stools, which he describes as *resembling amber in their external appearance*. The word *electrodes* also occurs in Callisen's *Lexicon Medicum* (Lipsiæ, 1713), and is said to signify, *succino similis*." Vide, *Selecta e Præscriptis*, ninth edition, p. 37, 1844.—The word ἠλεκτρώδης will be found in *Hederic's Lexicon*, 1821, described as electro-similis; (2.) de excretione cum splendicat et relucet. It appears as an English word in Dr. Parr's London Medical Dictionary, thus—*Electródes*, and it has a similar definition to Hederic's. Now, although the word, so far as literal orthography is concerned, is not so new to our language as we had imagined, yet, from the fact of the old word being compounded with εἶδος, and the new with ὁδος, the former produces the oxyton *electròdes*, and the latter the baryton *eléctrodes;* so that although Faraday has unwittingly, and by singular coincidence fallen upon the *letters* constituting an old word, we scarcely think the philologist would pronounce his *word* itself to be an old one, inasmuch as the place of the accent alone is an index to a different derivation, and the word itself is essentially distinct in sound.—*Ed. Elec. Mag.*

Digitized by Google

"*To give Polarity to a Needle.*—

Cinnabar
Realgar, male or female
Steel filings
} Equal quantities, reduced to fine powder.

Mixed up with blood (from a cock's crest). Cover the needles with the mixture; wrap them in paper, and put them into an oven, under which you will keep up a charcoal fire for seven days and nights. This done, wrap them, and carry them next your skin for three days; they will then serve for the mariner's compass."—*Père Entre Colles.* Jesuits' Letters from China.

Magnetization.—M. P. Elias, of Haarlem, has advised the use of a short instead of a long electro-magnetic coil; and he passes the coil from end to end along the steel bar, as in Duhamel or Mitchell's double pass. We have been present with Mr. Watkins at a repetition of this experiment, and it appears to be satisfactory. The account is in the *Annalen*, vol. lxii. p. 249, and is translated into the *Phil. Mag.* for Nov. 1844.—*Ed.*

"The most powerful electro-magnet of which I am aware, is one constructed under the direction of Mr. Faraday, for the magnetic observations of Col. Sabine, at Woolwich. It was exhibited at a lecture of his before the Royal Institution, on June 10, 1843. The helix is 27 in. long by $2\frac{3}{8}$ in. internal diam. It has four coils of No. 7 copper wire, covered with tape; their lengths are 108 feet 10 in., 120 feet, 129 feet 7 in., 143 feet,—in all, 510 feet 5 in. Bars and clamps are arranged so as to admit of using one or more of the helices variously combined. It is firmly supported on a grooved square stand. The soft iron core is 28 in. long by $2\frac{3}{8}$ in. diam. There are two other cores, each $12\frac{1}{2}$ in. by $2\frac{3}{8}$ in., for magnetising a steel bar *placed in the coil between them.*"—*Cab. Cyc.* Electricity. Charles V. Walker. Vol. ii. p. 508.

Copley Gold Medal awarded to Matteucci.—At the anniversary meeting of the Royal Society, held on the 30th of November, 1844, the Copley Gold Medal was awarded to Prof. C. Matteucci, for his researches in animal electricity.

Growing Potatoes by Galvanism.—On the 2nd July, Mr. Wm. Ross presented to the New York Farmers' Club, some potatoes measuring seven inches in circumference. He planted the seed potatoes in drills on the 6th May last, using only leaves for manure. Across three rows at one end he buried a sheet of copper, 5 feet long and 14 inches wide, and at the other end, 200 feet distant, a sheet of zinc of like dimensions. The sheets were placed in an upright position, and were connected by a copper wire, thus making a galvanic battery, the moisture of the earth completing the circuit. On the 15th, some potatoes were taken from these rows, varying from one inch to one inch and a quarter in diameter. On the 2nd July, others were dug that measured $2\frac{1}{2}$ inch. in diameter. Some of the adjoining rows, beyond the battery, were tried, but few of them had potatoes larger than marrowfat pease—certainly none larger than a boy's marble. Mr. Ross had made other experiments with electricity from a common Leyden jar, and by applying the charges three

Digitized by Google

times, he succeeded in producing cucumbers in the open ground, which measured five inches in length in thirty-seven days from the time of planting the seed.—*Mech. Mag.*, Sept. 28, 1844.

Longitude determinable by Electric Telegraphs.—When we gave a report of some experiments on this subject, by Prof. Morse (*vide Elec. Mag.*, No. 6, p. 471), the following passage had escaped our notice. We insert it now, as a contribution to the history of the application. The particulars had been communicated to M. Quetelet, by Prof. Wheatstone, who had also mentioned them to Prof. Airy, and others:—

"In a scientific point of view, the results that may be derived from Mr. Wheatstone's telegraph are immense. Thus, for localities through which the telegraphic line will pass, the determination of longitudes (one of the most delicate operations of practical astronomy) will not present the least difficulty. On the other hand, by a particular arrangement, a pendulum may give the time to the whole house, or to an entire town, or even to a whole country. The auxiliary clocks, that mark the hours, minutes, seconds, at the same moments as the regulating clock, consist merely of a simple face. Thus Mr. Wheatstone calls them *skeleton clocks*, and he estimates their price at one or two pounds sterling. The author also calculates on employing his processes for measuring, with a precision that he thinks may be carried to the hundredth of a second, the velocity of projectiles.* It would be difficult to limit the applications to which Mr. Wheatstone's ingenious apparatus may be turned."—*Bull. Roy. Acad.*, Brussels, 7th Oct., 1840.

Photographic Engraving.—M. Fizeau has described his recent improvements in engraving on Daguerréotype plates. He inserts the plate in a mixture of nitric, nitrous, and hydrochloric acids; by which means the black or silver parts of the picture are eroded; he then washes out the chloride of silver thus formed, with ammonia, and again immerses the plate in the acids, repeating the process several times. A certain depth of etching is thus produced. He then rubs linseed oil on the plate, and washes it off, so that the parts in relief may be still exposed; he now gilds these parts by the electro-process, and afterwards removes the oil by caustic potash; this being done he bites in the hollow parts with nitric acid, and so augments the depth at pleasure. Now, as silver would soon wear out in the press, he coats the whole surface with copper by electric deposition, and thus prepares the plate for use; and when one surface of copper commences to wear, he removes it by chemical means, and supplies its place with a fresh deposit.—*Comptes Rendus*, 8th July, 1844.

Hydro-Electric Machine.—A correspondent to the *Mechanics' Magazine* suggests, instead of insulating the boiler, to insulate the jet, by attaching it to a glass tube. Mr. Armstrong has long ago tried this; but the condensation of the vapour entirely destroys the insulation.—*Ed.*

Blasting by Galvanism.—"The galvanic apparatus made by our

* *Vide* also *Elec. Mag.* No. 6, p. 473.

Digitized by Google

ingenious townsmen, Messrs. Kemp, has been again successfully applied to the simultaneous ignition of a number of shots for the purpose of disintegrating a large mass of stone in the quarry of Rosyth Castle, about two miles above the Queensferry. The shots were arranged in a line, along a ledge of rock, 70 feet long, 9 feet broad, and between 7 and 8 feet thick. Being loaded with moderate charges of gunpowder, and connected by the conducting wires of a large and powerful galvanic battery, and all the other preliminary preparations effected, immediately on completing the galvanic circle, eleven shots, which had been charged with about 35 lbs. of gunpowder, were instantaneously fired; and so great was the concentrated power of the simultaneous explosion, that the whole mass in front of the bores was instantly separated from the contiguous rock; the separated portion containing a mass of no less than 3780 cubic feet of stone, and weighing upwards of 260 tons."—*Edinburgh Witness.*

Electro-telegraphy in France.—The French papers announce a recommendation by the king, of a large grant of money for establishing an extensive system of telegraphic communication; and they speak very favourably of Prof. Wheatstone's magneto-electric telegraphs, which will be adopted.—*Ed.*

"*A Waterspout.*—The French papers contain the following account of the ravages committed by a waterspout, the details of which are contained in a letter from Cette, of the 22d instant:—'A frightful misfortune has this afternoon plunged our whole population into a state of consternation and despair. About four o'clock an electric waterspout fell upon our town, and committed such ravages that at the present moment it might be supposed that the town had been submitted to all the horrors of a siege. This terrible phenomenon, which arrived in the direction of the fortress of St. Pierre, skirted the mole in its whole length; and when it came opposite the engineers' establishment, attracted probably by the conductor and the zinc roof of the house, it turned round the edifice, and at last fell with violence upon it. At the same moment a violent explosion was heard, and the whole population thought that its last hour was come. During two minutes' space of time a terrific crash resounded in the air. The roofs of the houses were smashed to pieces, and the fragments were carried to the most distant part of the town. The building belonging to the engineers has been entirely sacked, its zinc roof was carried off in the twinkling of an eye, and the whole *façade* demolished and razed to the ground; so that nothing now remains of it but the back and side walls. Another house, four stories high, new and solidly built, belonging to M. Labaille, was literally crushed to the earth. In every apartment the separation walls were destroyed, the windows torn out; everywhere destructive traces have been left. Never in the memory of man has so frightful a catastrophe been witnessed in our town. Alas! however, we have still further misfortunes to narrate. A fearful inundation joined at the same time its ravages to those of the electric waterspout. In an instant the waters of the canal rose

Digitized by Google

and flooded the quays. It was a pitiable spectacle to see all the lighters loaded with wines torn into the current, driven one against the other, and then swallowed up by the element. At least a dozen boats were sunk in the canal itself, and what was the most terrible is, that most of them had their crews on board. Some few were able to save themselves, the others have perished. It is supposed that nearly thirty have been carried down with their boats. Five or six large vessels have been completely wrecked, and remain with their keels uppermost. As to the lesser injuries done among the masts, rigging, &c., they are innumerable. In the streets and on the quays are everywhere to be seen wounded wretches, some with bloody heads, others with mutilated limbs. A body has just been dug out of the ruins of the house belonging to the engineers. In front of the Cafe de la Bourse, a merchant of this town, M. François Lavatre, was crushed beneath the ruins of a huge structure belonging to a party of strolling players, stationed at the extremity of the old bridge. Persons are missing in their families, and it is to be feared that they have perished in this awful storm. It is impossible to give any description of the feelings of terror produced in the minds of the whole population. Persons are to be met with in every street running to and fro demanding news of different members of their families; and it is with fear and trembling that each asks the other, "Is there no one destroyed in your house?" We are unable, from the lateness of the hour, to give any further details; but those already given are exact, although a feeble picture of the horrors that surround us. At this moment a violent south-east wind is blowing. Grant, Heaven, that we have not to give more wretched details to-morrow.'"—*Times*, Oct. 30, 1844.

Calculus of the Bladder treated by Electricity.—Sir,—A "Sufferer" imploringly asks in your last number whether you know anything of a method for the cure of stone by electricity, and seems justly to estimate its importance. For his comfort I beg to inform him that there is such a method, and, I believe, a successful one. The author of it, whom at present I have no authority to name publicly, was so good as to call on me, about a fortnight ago, with a patient on whom he had successfully operated, in order to show me what had been done. The man was perfectly well after, I think, about two months' treatment. I questioned him as to his previous suffering, and there can be no doubt that he had laboured under very aggravated symptoms of stone in the bladder. He had, moreover, been sounded, I was told, at one of the Borough hospitals, by an eminent surgeon, whose opinion was that there was a large calculus. The physician who brought him to me informed me that it was a very large lithic acid calculus that had been decomposed. I presume that very soon the subject will be brought before the profession and the public. I am, Sir, your obedient servant, Wm. Maclure. Harley-street, Aug. 5, 1844.—*Lancet*, Aug. 10, 1844.

Omnia.—M. Louyer, of Brussels, thinks that the superiority of an acid over an alkaline solution for electro-zincing iron, is due to the acid of the solution preventing the formation of a film

Digitized by Google

of oxide on the iron; he thinks that in zincing, the *mass* of the object influences the result.—M. Mayer describes a *pseudo-electric organ* in certain rays which do not give shocks.—M. Ducros submitted several memoirs to the French Academy in July last, on the part played by electricity in the circulation of the blood.—In France, M. Christofle offers a prize of 2000 francs for the best legal project for regulating the industrial employment of electrolytic forces, so as to prevent fraud; in England, the officers of the Mint, on searching the premises of some coiners, discovered Smee's batteries, silver solutions, and electro-plated spurious coin.—A game of draughts is said to have been played between the cities of Baltimore and Washington by means of Morse's telegraph.—A hydro-electric machine, four times more powerful than that at the Polytechnic Institution, is being constructed for the United States; it is to be called "The Benjamin Franklin."—We have succeeded in obtaining the reduction of brass by the method described, in the present Number, by M. Jacobi.—A Mr. Benningfield, of New Jersey, describes an electric gun.

PROFESSOR DANIELL.—It is our painful duty to record the awfully sudden death of Professor Daniell, a philosopher whose name has become a household word to the electrician, and will always be remembered in connection with his admirable discovery of the Constant Battery, and his other contributions to electrical science. As professor at King's College, London, he was engaged in delivering a course of lectures on "Current Affinity," or Electro-Chemistry. We had the good fortune of being present at several of these lectures, but were unwillingly absent on Thursday the 13th of March. On the afternoon of that day he lectured with his accustomed good spirits and in his usual cheerful manner, and concluded his lecture a few minutes before four o'clock, in order to be present at his place at the council-board of the Royal Society, of which he was foreign secretary. Before leaving the lecture-room, he conversed with his well-known courtesy with some who were present; and making some lively remarks to a student, who was interested in the subject of the lecture, he went to the Royal Society's apartments, which are at Somerset House, close at hand. Within less than an hour from this time he was no more. Dr. Bowman, who sat opposite to him at the council-table, observed a strange fixedness in his eyes, and at first thought him to be in a fit. With the concurrence of those present, he opened a vein in the neck, but it was of no avail; the hand of death was upon him, and all human means were powerless. A few minutes elapsed, and all was over. The cause of his death was apoplexy, to which he had a constitutional tendency. His age was fifty-five years.

Digitized by Google

INDEX TO NAMES.

A.

Abria, 71. 344
Addams, Robert, 289, 290
Æpinus, 222
Aimé, 313
Ainsworth, 393
Airy, 602. 611
Albert, The Prince, 285
Ampère, 202. 344, 345. 356. 572-575. 591
Amyot, 509. 513
Anselin, 149
Antinori, 80. 540
Arago, 41. 77. 80. 82. 84. 144, 145. 153. 173. 325. 332. 335. 348. 471. 514. 543. 562. 587. 598
Archer, Mr. 508
Armstrong, 61. 64. 122. 124, 125. 127. 129. 210. 231. 285-291. 450. 454. 459. 463. 499. 503. 536. 612
Arnott, Dr. 467
Arrott, 65
Augustus, 143

B.

Bachhoffner, 127. 150. 281. 527
Bagration, Prince, 322. 324. 394. 524. 594
Baillière, H. 149. 228
Bain, 50. 52. 112, 113. 115. 139-142. 150. 191, 192. 228. 392. 443. 520, 521. 592. 606
Banks, Sir Joseph, 141
Barbier de Tinan, 168
Barlow, 377. 571, 572
Bary, M. E. 471
Baudieri, 335
Bauer, 308
Beatson, William, 555. 559
Beccaria, 536. 553
Becquérel, 25. 31. 35. 68. 75. 77. 85. 100. 108. 111. 148. 201. 209. 228, 229. 251. 307. 312. 315. 444, 445. 467. 469. 486. 536. 547. 561. 570. 595. 597
Becquérel, Edm. 31. 320. 445
Beil, 308
Belcher, Sir E. 217
Bell, Sir Ch. 490. 493
Belli, 593
Bellingeri, 490
Benningfield, 614
Berger, 300
Berzelius, 307. 382. 608
Bevis, 536
Billand, 389
Billing, Dr. 542
Biot, 217. 343. 376. 509. 571
Bird, Dr. Golding, 229. 280. 303. 551
Blackwood, 390
Bohnenberger, 153. 248
Bonham, Lieut. 397. 404
Bordé, Prof. 551
Botto, 228. 299. 550
Bouquillon, 40. 77
Bowman, Mr. 542. 614
Brande, 232
Brayley, E. W. 540
Breguet, 29. 34. 36. 338. 342. 498, 499
Briant, 302
Brooke, 527
Brown, Capt. 393
Brugnatelli, 236. 315
Buckland, Dr. 604
Buddle, 286
Bunsen, 16. 19. 22-28. 36. 70. 232. 325. 330. 389. 526. 588
Burton, Frances B. 602
Bush, Wm. 606

C.

Callisen, 609
Cancrin, Count, 302
Canton, 153
Carr, Lieut. 472
Cellini, Benv. 365
Chalmers, 147
Chapman and Hall, 139
Chapsal, L'Abbé, 562
Chariet, 551
Charles, 152
Cheek, 393
Chi-hou, 511
Chladni, 153
Christofle, 76. 614
Cima, 590
Clarke, E. M. 81. 335
Colt, Mr. S. 507, 508
Columbus, 540
Connell, 387

Digitized by Google

Cook, Capt. 514
Cook, Mr. 400
Cooke, W. F. 64. 604
Cooper, 70
Coulomb, 71, 72. 107. 217. 536
Crahay, 418. 421, 422. 424. 428. 432
Crosse, Andrew, 210. 303, 304. 368. 370. 380. 422. 519
Crusell, 551
Cuthbertson, 290

D.

Daguerre, 82. 327. 394
Dalton, Dr. 604
Daniell, 24. 29, 30. 37-40. 69. 78. 100-102. 112. 115. 179, 180. 184. 188. 204. 232, 233. 322. 324. 381, 382. 384. 438-440. 442. 519. 529. 536. 542. 559. 568, 569. 614
D'Arcet, 97. 219
Davy, B. 416
Davy, Dr. 540
Davy, Mr. 140
Davy, Sir H. 101. 232. 236. 325. 334. 382. 518. 536. 540. 543
De Blainville, 45. 549
De Freycinet, 307
De Haldat, 107, 108. 151. 153. 353. 550. 597. 599
De Humboldt, 48. 509. 549
De la Rive, 24. 28. 30. 40. 72. 75. 77, 78. 95. 100. 149. 153. 228. 235, 236. 247. 307. 310, 311. 315. 333, 334. 346. 467. 469. 519. 536, 537. 551
De la Rue, 60
Deluc, 416. 536
Deluca, 336
Dentone, 43
De Ruolz, 75. 95. 554. 559. 561
De Saussure, 407
Desbordeaux, 605
Despretz, 498
De Valincourt, 550
Diebold, 169
Dircks, 605
Döbereiner, 443
Döbler, Herr, 552
Dove, 82. 342. 385
Draper, 166. 234. 448. 602
Drummond, 19
Ducros, 614
Duhamel, 610
Dujardin, 313
Dulong, 498
Dumas, 84
Duperrey, 307. 471. 509. 514. 605
Duport, St. Clair, 95
Duprez, 391
Durer, Albert, 605

E.

Editor, The, 112. 122. 150. 153. 190. 233. 293. 310. 312. 552. 586
Eld, Lieut., 472
Elias, M. P., 610
Elice, Dr., 43. 45. 153. 307. 387. 602
Elkington, 63. 74. 75. 95. 97. 151, 152. 219. 230. 233. 302. 305. 363. 554. 601
Elliot, Mr., 503
Ely, Dean of, 137
Entre Colles, 610
Ermann, 407

F.

Fabroni, 536
Faraday, 22. 33. 46. 50. 55-57. 60-63. 66, 67. 71. 77. 80, 81. 100, 101. 122. 124, 125. 210. 226. 228, 229. 231. 281. 289. 295. 297, 298. 302. 309. 320. 337. 344. 451. 454. 467. 469. 529. 536. 538. 540-542. 548-550. 599. 604. 609. 610
Fargeaud, 167, 168. 228
Favre, 313
Fechner, 203. 587
Fiedler, 229, 230
Fieschi, 233
Fincke, 172
Finlaison, 51. 115. 139. 141. 192.
Fisher, Prof., 74
Fitzroy, Capt., 399
Fizeau, 325. 333. 611
Flourens, 48
Forbes, Prof., 447
Forster, 604
Fortin, Masson, and Co., 71. 490. 542
Foucault, 325. 329. 333
Fox, R. W., 190-192. 230
Francis, G., 300. 307
Franklin, 5. 167, 168. 536. 550. 614
Frankenstein, 550
Frederick of Turckeim, 168
Freycinet, 605
Fries, 168, 169
Fusinieri, 235. 247. 252. 274. 315. 318

G.

Galletti, 307
Galvani, 480. 536. 543, 544. 550. 554
Galvani, Lucia, 543
Garnier, 554. 603
Gassiot, 28. 53. 55. 59. 74. 100. 105, 106. 150. 195. 271. 284. 290. 334. 380, 381. 463. 465. 470. 519. 535-537. 542. 600
Gaubil, 509. 511. 513
Gaudin, 517
Gauss, 215, 216
Gay-Lussac, 144. 168. 540

Digitized by Google

George the Third, 554
Gerard, F., 550
Gilbert, 536. 570
Gioia, 550
Glaser, 228
Glauber, 62
Glenn, 386, 387
Goodman, J., 535
Gourgon, 609
Graham, 382. 530
Grey, 536
Grimelli, 550. 602
Grotthus, 199. 315
Grove, 16. 18-20. 24. 26-31. 34-40. 54, 55. 57-59. 64-66. 70. 78. 100. 104, 105. 108. 111. 118. 122. 155-162. 164. 193-201. 220, 221. 232. 278. 294. 298, 299. 314. 381. 392. 434. 436-440. 464. 467. 469. 519. 527, 528. 535-537. 599. 601
Guericke, 536

H.

Haldemon, 309
Hall, 48
Hall, Dr. Marshall, 542
Han, 510
Han-feï-tseu, 610
Hankel, Dr., 501. 503
Hansteen, 570, 571
Hare, Dr., 69. 315. 518. 538. 541
Harel, Ch., 603
Harper, Lieut. F., 403
Harris, W. Snow, 142. 144-147, 152, 153. 229. 301. 395. 399. 470. 471
Hawkesbee, 536
Hederic, 609
Heighton, Rev. H., 472. 606
Henley, 474
Henrici, 31. 228. 232
Henry, Prof., 228. 350. 352. 444, 445. 448, 449
Hericart de Thury, 77
Herman, 168
Herrenschneider, 168
Herschel, Sir J., 214
Hervey, G., 416
Hien-thsoung, 511
Higgins, Wm., 550
Hippocrates, 609
Hoang-ti, 510
Homburg, 444
Hopkins, Evan, 307. 541
Horace, 279
Hudibras, 608
Hunt, 314. 535, 536
Husson, 168

I.

Ibbetson, Capt. 124. 527. 535

J.

Jacobi, 138. 180. 186. 203. 228. 322. 356. 390. 536. 554. 559. 561. 587. 592. 604
James, King, 390
Jameson, 387
Jewreinoff, 151
Jin-thsoung, 511
Jones, Adj.-Gen., 508
Joule, J. P., 67. 138. 178. 209. 528
Jounin, 307
Julien, M. S., 509. 511. 513

K.

Kaemtz, 407. 471. 609
Karstan, 5. 8. 42, 43. 82
Keferstein, 501
Keil, 602
Kemp, 192. 204. 393
Kemp, Messrs., 612
Klaproth, 509. 511-513
Klotz, 172
Knight and Sons, 112. 228. 302
Knight, Dr., 222, 226
Knorr, 42
Knox, 209
Kreil, 216
Kupffer, 391. 471. 550

L.

Labaille, 613
Lacombe, 168
Lamont, 307. 387. 550. 609
Lane, 11
Laplace, 408
Lardner, 147, 148. 229
Lavatre, F., 613
Lavoisier, 408
Leath, Capt., 403
Lefranc, 268
Lefroy, 217
Lehot, 490
Lenz, 164. 166. 203. 438
Letheby, Dr., 549
Lettsom, W. G., 5. 8, 9. 247. 309. 433. 528. 554
Lichtenberg, 84. 153
Liebeg, 302. 394
Lloyd, Prof., 210. 216, 217. 471
Lockey, Rev. F., 279. 281. 303. 361. 363. 391. 394. 605
Lockwood, 71
Longet, 471. 490. 493. 614
Longman and Co., 147. 222. 227
Louyet, 550
Love, Hy., 397

M.

Macintosh, 502
Mackrell, 277. 279. 334

Digitized by Google

Maclure, 613
Magarotto, 243
Mahomet, 394
Majocchi, Prof., 153. 275. 277. 292
Mallett, 68
Mallory, 508
Mangrini, 593
Marianini, 490
Marrian, Mr., 527, 528. 555
Marsh, 503
Martens, 31. 315. 439
Martins, 407
Masson, 41, 42. 82. 228. 272
Matteucci, 45. 71. 108. 153. 174, 175. 307. 389. 445. 471. 474, 475. 482. 490. 497. 536, 537. 542. 544. 546, 547. 549. 552. 554. 587. 593. 595-597. 601. 604. 610
May, 397
Mayor, 614
M'Cullock, Jas., 360, 361
Meillet, 151
Melloni, 80. 335. 445. 568. 604
Meunier, 168
Miles, 508
Millar, Dr. 381. 384. 529. 542
Ming, 513
Mitchell, 74
Mitchell, Wm., 309
Moan, M. Planta, 551
Montyon, 75
Morison, 607
Morren, 41. 84. 554
Morse, 70. 74. 140. 164. 226. 471, 472. 520. 611. 614
Moser, 5, 6. 12-15. 41, 42. 82, 83. 175. 535
Mourey, 75. 77. 94
Muller, 48
Murray, 602
Muschoenbrock, 236. 536

N.

Napier, Jas., 499. 501. 503. 554. 601
Negro, 540
Newton, 260
Nganti, 510
Nichol, 447
Nichol, Dr., 471
Noad, H. M., 228, 229. 250. 303. 368
Nobili, 80. 100. 252. 255. 271. 353. 486. 490. 540. 588
Nollet, 536
Norcolt, Capt., 399
Nott, Jno., 132. 292, 293. 358. 371

O.

Oersted, 277. 345. 385. 475. 536
Ohm, 2. 102. 201. 346
Onslow, Capt., 400

P.

Pacinotti, 590
Page, Prof., 554
Palmieri, 80. 82. 335
Papin, 453
Paris, Dr., 543
Parker, 142
Parker, Capt. Hyde, 398
Parr, 607
Parr, Dr., 609
Patterson, 453
Peclet, 202, 203. 468
Pellatt, 63. 219. 230
Peltier, 56. 178. 311. 391. 407, 408. 410. 412. 416-419. 421. 424-428. 432. 450. 453. 551. 562
Pepys, 536
Pereira, 290. 542
Petrina, 247. 250
Pfaff, 608
Pinaud, 174
Phillips, 230
Phillips, Richard, 540
Plantamour, 307
Plateau, 418
Poggendorff, 5. 8. 19. 22. 24. 71. 82. 156. 158. 247. 392. 433, 434. 501. 587
Poisson, 215. 343
Pollock, 278. 293. 449. 503
Poole, 388
Porret, 315. 531
Potter, F., 217-219
Pouillet, 153. 203. 207. 551. 565. 587
Priestley, Dr., 174. 251, 252. 255. 282. 389. 536
Pring, Dr., 154. 441
Pritchard, Rev. C., 470

Q.

Quetelet, 307. 390, 391. 416. 418. 450. 454. 456. 471. 552. 609. 611

R.

Ramslett, Lieut., 231
Redier, 151, 152
Reed, Capt. A., 400, 401
Regnault, 22
Reizet, 22. 25, 26. 389
Renshaw, 602
Rhein, 169. 171
Riadore, 551
Ridolphi, 590
Riess, 5. 82.
Ritchie, 166. 280. 524
Ritter, 433. 488. 536
Roberts, Martyn, 284. 358, 359. 524. 536
Ronalds, 474
Rondoni, 554

Digitized by Google

Ross, Capt., 215
Ross, Wm., 610, 611
Rosler, 550
Rousseau, 603
Rowlett, Mr., 399
Rozier, 404
Ruhmkorff, 81. 478. 496
Rumford, Count, 189
Roulz, Count de, 305
Ruschi, 590
Russel, Mr. 188

S.

Sabine, Col. 215, 216. 227. 229. 610
Sadler, Mr. 398. 404
Santi-Linari, 80. 82. 335
Savart, 73
Savi, Paul, 50. 307. 471. 541. 550
Sbragia, 590
Schiller, 229
Schœnbein, Prof. 31. 64-66. 109. 153. 197. 310, 311. 383. 386. 472. 540. 554
Schweigger, 280. 356
Scoresby, 136, 137. 181. 209. 222. 229. 535
Seebeck, 536
Sellien, 311
Semmola, 336
Sharpe, Capt. 401
Shaw, G. 471
Silliman, 70. 74. 162. 232. 309. 315
Silliman, B., Jun. 70
Simon, 151, 152
Simpkin and Co. 471. 602
Smee, 41. 54, 55. 59, 60. 113. 229. 270. 362. 531. 536. 555. 557. 602. 606. 614
Smith, Archibald, 214
Sommé, Dr. 608
Soung, 511
Spindler, 168
Sse-ma-thsien, 510
Steinheil, 64. 392, 393
Stewart, Capt. J. 283, 284
Storer, Dr. 74. 232
Sturgeon, 284
Sullivan, Capt. 398. 404
Swammerdam, 543

T.

Talbot, R. Fox, 392
Taylor, John, 147
Taylor, Richard, 65. 100. 295. 538. 541
Tcheou-kong, 510
Tching, 513
Thang, 511
Thesinger, 607
Thompson, 74
Thompson, R. W. 312
Thompson, Sir T. 402
Thsouï-pao, 510
Todd, Dr. 542
Toscan, 147
Tsin, 510, 511
Tuck, E. 310
Turner, Capt. 399
Tuscany, Grand Duke of, 543. 589
Tylee, 232. 442

U.

Ure, Dr. 458
Vail, Mr. 472
Veith, 5
Vetzholdt, Von Alex. 550
Victoria, Queen, 553
Viloftoff, Gen. 324
Volta, 44. 57. 85. 163. 408. 464. 536. 544
Voltz, 168
Von Jewreinoff, 302
Von Kleest, 536
Von Kobel, 554

W.

Wadham, 361. 392
Wagner, 172. 303. 609
Wade, Arthur, 458
Walker, Charles V. 115. 127. 193. 229. 279. 281. 285. 292. 304. 469. 471. 503. 506. 527, 528. 609, 610
Warner, Capt. 507
Warrington, 305
Wartman, Elie, 337. 344. 346
Watkins, 234. 381. 527
Watkins and Hill, 290. 306, 307. 384, 385. 337
Watson, 536
Watson and Lambert, 286. 289. 536
Weekes, 250. 309. 510. 528. 554
Welsh, 402
Werner, F. 302
Wertheim, 605
Wheatstone, Prof. 64. 100. 102-104. 135. 139-141. 201. 203, 204. 207. 212. 228. 232. 346-350. 362. 385, 386. 390. 438. 473, 474. 536. 542. 587. 604. 609. 611, 612
Wiley and Putnam, 602
Wilkes, Capt. C. 472
Williams, 605
Willis, 493
Wollaston, 101. 392. 536. 605
Woolrich, 310
Woulfe, 195

Y.

Yang-ti, 515
Yardley, 150
Young, 352

Z.

Zamboni, 381. 464. 470. 551
Zantedeschi, 307. 315. 386, 387. 471. 550

Digitized by Google

ANALYTIC INDEX.

A.

Absolutism in nature, none, 58
Acid and alkaline reaction, electric, 483
Adhesion of deposits, 94
,, ,, nascent gases, 32
Adulteration of oil detected, 603
Aëorolytes, origin of, 244
Air-gun discharge, electrical, 45
Air-jets, electrical, 131
Aix-la-Chapelle, electro-telegraphs, 64
Alkaline solution of lead, 256
Alloys, not reducible, 60
,, of refractory metals, 601
,, reduced by electrolysis, 393, 559
Alternate functions to electrodes, 33
Amalgamated rod for hydro-electro machines, 286. 288
Amalgamated zinc introduced, 204
Amalgamation before plating, 97
Amalgam of potassium, pos. element, 104
,, ,, sodium, pos. element, 232
,, ,, zinc, pos-element, 104
Ammoniacal solution of iron, 93
Anhydrous peroxide of lead, 88
Animal electricity, 45, 475, 544
,, heat consumed by work, 189
Annales de Chimie, 71
Anode, relative destruction of, 601
,, when inactive, 119
Antarctic expedition, 214
Architects, to study lightning-flashes, 143
Archives de l'Electricite, 149. 228
Artificial lightning, 43
,, suns, 517
Atmospheric apparatus, 368
,, electricity, 56. 132. 390. 407. 412. 428
,, ,, collected 214
,, ,, whence ? 60
,, pressure opposes electrolysis, 32
Atom, application of term, 295
Aurora Borealis, artificial, 126. 372
,, ,, in China, 509. 514
,, ,, magnetic character of, 216. 227
,, ,, theory of, 135
Azote, decomposed, 384

B.

Ball-electrometer, Peltier's, 407
Ball-lightning, case of, 283
Barometer registered by electr. 212
Battery, Bunsen's, power of, 330
Battery power increased, 30
Black appearance of electrodes, 34
,, its conducting power, 311
,, lead superseded, 366
,, powder in electrolysis, 72
Blasting battery, Roberts's, 524
,, by electricity, 312
,, ,, galvanism, 612
,, ,, magneto-electricity, 234
Borax in electro-plating, 76
Brass, magnetization of, 371
,, reduced by electrolysis, 554. 559
Breguet's thermometer, 29. 34
British association, 132. 209. 535
Bromine paper for electrographs, 175
Bronze imitated by thin films, 90
,, reduced by electrolysis, 554. 559
Building in China by compass, 512
Bunsen's battery, 19. 23. 25
Buried plates, 323, 324. 520. 524. 605
,, ,, action of, 51. 192. 279. 393.
,, ,, applied, 392

C.

Cadmium, positive element, 32, 33
Calculi reduced by electricity, 613
Capacity for magnetism, 222
Carbon battery, 70. 232
,, electrodes, 22
,, for buried plates, 526
,, for negative element, 16
,, points, 329
,, preparation of, 360
Carrier-balls, use of, 55, 56. 66
Cars, Chinese directive, 510
Catalytic action, 162
Cathode, ignition of, 278
Cause and effect convertible, 221
Centres of force, matter, 297
Chemical heat, electric origin of, 67
Chemical and Voltaic actions, correlative, 57. 68
Chemical changes by radiant light, 234
,, effects, not static results, 467

Digitized by Google

Chinese employed the compass, 510
Chlor-hydrogen battery, 160. 198
Chloro-zinc battery, 198
Churches struck by lightning, 142
Cleansing solutions for medals, 96
Clock, electrical, 362
,, galvanic, 361
Cloud, electr. of, 368
,, grey resinous, 410
,, white, vitreous, 410
,, of pith-balls, 420. 424, 425. 428. 433
Coffee-grinding electrical, 503
Coke and coal for artificial carbon, 17
,, for negative element, 151
Cold produced by electricity, 177
,, ,, by magneto-electr., 138
Colossal electrical machine, 126
Coloration of metals, 251. 259. 268
Coloured films made permanent, 267
,, rings, 252, 271
Colour, index to electr. of cloud, 391
,, of clouds related to electr. 423
,, of electric light, cause of, 599
Combination of electro-films wanting, 96
Combinations of magnets, 223
Combustion and conduction of flame, 250
Combustion at cathode, 121
Commutator, Wheatstone's, 102
Compass-needle, steel for, 224, 225
Compensator for galvanometer, 478
Concentrated electro-magnetism, 394
Condenser, voltaic, 38
Conductibility of the earth, 687. 593. 595
Conducting power of wires, 166
,, wires physically altered, 528
,, ,, sonorous vibration of, 557
Conduction of long wires, 228
,, , speculations touching, 295
Conductors for ships, 144
,, struck with lightning, 397
Constant battery, 26, 605
,, ,, Bagration's, 322
,, ,, type of, 85
Contact and separation, 301
,, electricity without, 57
,, force improbable, 69
,, theory, 469
,, ,, what is it? 200
,, what it affects, 467
Copley medal to Matteucci, 610
Coppering liquor, 310
Copper solution, 389
,, ,, improvement in, 366
,, wire, sonorous vibration of, 558
Cornwall mines, experiments in, 575
Correlation of forces, 220, 599
Creation of power in contact theory, 70
Crust of globe, its composition, 578
Current, a series of discharges, 381
,, intensity related to chem. action, 348
,, and muscular contraction related, 490
Currents of air do not discharge, 249
,, of the earth, 570
Curves of conducting powers, 165
,, of magnetic capacities, 224
Cyanide double, electrolysis of, 554
,, fumes unwholesome, 218
,, of brass and potassium, 559
Cypress-tree tends to west, 512

D.

Daguerreo-plates by electrolysis, 394
,, ,, for photometry, 327
Daguerreotype prints, 554
Daguerreotypes and electrical pictures, 14
,, ,, coloured, 554
Daniell's pile contrasted with peroxide of lead pile, 37
Declination observed in China, 512
Decomposition by single pair, 31
Deflagrator, Hare's, 518
Delineations, magnetic, 210
Depolarization of electrodes, 36
Depolarizers, 162
Deposition of metals not new, 392
Derived current, 488. 544
Detonations of charcoal flame, 73
Diagometer, 603
Diaphragm-battery, 233
,, cell, double, 529
Diaphragms, 102
Differential current, 488
,, resistance measurer, 208. 386
Dip in China, 514
Direct current, 490
Direction of current in electric organ, 49
Disc experiment, 57
Discs of carbon, 18
,, thin, magneto-electric, 599
Disguised electricity, none, 67
Disturbance, magnetic, general, 216
,, observations, 215. 227
Division of lightning discharge, 171. 173
Double salts, electrolysis of, 382
Dry method of cleaning metals, 97
,, pile produces electric pictures, 84
Durertype, 605
Dyeing, electricity in, 499
Dynamic effects differ from static, 563
Dynamic effects follow static, 381. 466
,, ,, diff., 467

Digitized by Google

E.
Earth, conductor for telegraphs, 64. 586
,, ,, of electricity, 50
,, generator of electricity, 50
,, resinous, 408, 412
Electropeter in electrolysis, 33, 34
Electrical apparatus at Greenwich, 474
,, experiments, 300
,, light, its chemical action, 234
,, machine, Roberts's, 358
,, magazine, its features, 2
,, safety-lamp, 393
,, science much unknown,
,, soirée, Mr. Gassiot's, 537
,, spring, constant, 304
,, ,, intermittent, 304
Electric apparatus, catalogue of, 306
,, clocks, 606
Electric flame doubled, 389
,, fluid, not isolated yet, 245
,, ,, real nature of, 386
,, force of transferred matter, 244
Electricity and heat analogous, 535
,, and thermography, 313
,, applied, 231
,, Grove's course on, 536
,, Lardner's, 147
,, motive power of, 308
,, not a fluid, 120
,, of metals, 544
,, of mountains, 391
,, of steam, Faraday on, 129
,, of waterfalls, 391
,, prize in, 552
,, without contact, 463. 535.
Electric light not due to matter, 274
,, ,, whence, 235
,, lobe of the brain, 549
,, organ, experiments on, 46
,, ,, its relations, 548
,, phenomena, 424
,, pictures, 5. 8. 41, 42. 84. 174. 554
,, spark not pure fluid, 243
,, ,, permanently traced, 177
,, telegraph and railways, 553
,, ,, for police uses, 604
Electro-chemical copying book, 554
,, ,, laws, 320
,, chronoscopes, 473
,, cloth, 230
,, cloth, patent, 230
,, coppering, 74. 219
,, cultural Society, 604
,, culture, 610
,, deposits, hard, 364
,, dynamic sphere, 374
,, etching, 154
Electrodes alternated, 33, 34
,, and electrodes, 609
Electrodes, ignition of, 600
,, to be depolarized, 36
Electrographs, 174. 177
Electrolasmas, 303
Electro-lithotomy, 150, 613
Electrolysis, 387
,, by hydro-electric machine, 125
,, of salts, 69
Electrolytes classified, 534
Electro-magnetic clocks, 139
,, ,, engine, not attained, 189
,, ,, machine, 299. 609
,, ,, meteorological register, 212
,, ,, powder modified, 554
,, ,, rotations, 540
,, ,, sphere, Barlow's, 572
,, ,, telegraph, 64, 102. 139
,, ,, vibrations, 555
,, magnetism, animal, 608
,, ,, in sport, 554
,, metallurgy, 59
,, ,, applied, 305, 363
,, ,, manual of, 471
,, meteorological register, 103
,, motive force defined, 201. 347
,, ,, ,, increased, 392. 433
,, ,, ,, of the earth, 594
,, ,, forces summed up, 205
Electophorus modified, 303
Electro-physiology, 475
,, ,, Matteucci's experiments, 542
,, ,, treatise on, 542
Electro-plate, advantages of, 365
,, ,, factory, 554
,, ,, wears well, 305
,, plating, 75. 151
,, ,, and gilding, 302. 310
,, ,, non-adhesion of, 218
,, ,, not a combination, 96
,, ,, pirated, 151
Electroscope, double, 466
,, Gassiot's, 381. 464
,, gold-leaf, 481
,, Majocchi's, 153
Electro-silver, pure, 217
,, specula, 392
,, telegraph, 392
,, ,, thermometer, 135
,, telegraphy, 606
,, ,, in France, 612
,, tint, 60
Electrotype aiding organic analysis, 68
,, ,, plater, 217
,, by buried plates, 52
,, by native pairs, 191
,, manipulation, 302

Digitized by Google

Electrotype moulds, place of, 60
,, surfaces, 535
,, with rheostat, 204
Electro-zincing, 63. 74. 219. 367
Endosmoscope, 318
Endosmose, effects of, 27. 93
England, electricity in, 100
Epping Forest, experiments in, 51
Equilibrium, place of, 422, 423
Equivalent of electricity, 321
,, of zinc, 313
Equivalents, law of definite, 320
Escape of springs, measured, 565
Eudiometry by gas-battery, 199
Evaporation, electricity of, 61
,, not cause of steam electricity, 62
,, not chemico-electrical, 452
,, resinous, 409
Expansive force of matter, 246, 247
Experimental researches, 538

F.

Falling bodies, their velocity measured, 473
Faraday, a true philosopher, 538. 541
Ferro-cyanides, electrolysis of, 531
Fire-balls, theory of, 147
Flame, its conducting influence, 247
,, not electrical, 248
,, surrounding lightning-rod, 404
,, to collect electricity, 408
Flowers, electrotyped, 94
Fluorine, electro-negative, 209
Fog, artificial, illustration of, 420
,, different species of, 416
,, dry, 412
,, electricity of, 368
,, invisible, 420
,, observations on, Peltier's, 418. 424
,, resinous from evaporation, 417. 419, 420
,, ,, not wet, 419
,, simple from condensation, 417
,, theory of, 416. 421
,, vitreous, from induction, 417
,, white, vitreous, 423
Force, relative, of size of elements, 205
Fracture of Leyden jars, 281
Frequency, 553
Frictional electricity, 311
Friction and electricity of steam, 65
Friction excites hydro-electric machine, 62. 101. 124. 287
Frog alone has proper current, 547
,, galvanoscopic, 480
,, mechanical force from, 497
,, mode of preparing, 542
,, not casual to Galvani, 544
Fulgurites, remarkable, 229

G.

Galvani anticipated, 543
Galvanic battery, new form of, 441
,, experiments, 443
,, rings, 551, 607
,, wasp, 280
Galvani's daring experiment, 554
,, researches, 543
Galvanometer applied in electro-physiology, 478
,, astatic, 476
,, delicate, for all currents, 207
,, for atmospheric electr. 474
,, for infinitessimal measures, 567
,, Fox's, 230
,, how to restore, 477
,, in a storm, 609
,, its principles, 475
,, its resistance, 205
,, Joule's, 209
,, Majocchi's universal, 375
,, requires time, 565
,, to be tested, 479
Galvanometric degrees estimated, 208
Galvanoplastic, 394
Galvanoscopic frog, 480. 545
Gangues defined, 579
Gas and water pipes electromotors, 150
Gaseous battery, 57. 104. 155. 193
,, ,, a secondary pile, 434
,, ,, examination of, 108
,, ,, observations on, 65
,, ,, static effects of, 469
Gauze cylinders for induction, 57. 71. 101
Geology and terrestrial magnetism, 541
German silver and iron, thermo pairs, 388
Gilded surfaces, aspects of, 99
Gilding liquor, 310
Gold and copper alloy reduced, 561
,, soluble in cyanide of potassium, 394
Graphite for base of lightning-rod, 505
,, formation of, 335
,, for negative element, 17
Great Western Railway telegraph, 64
Grove's and Bunsen's battery compared, 24
,, battery, 27
,, ,, a hundred cells of, 105. 537
,, ,, experiments with, 164
,, ,, modified, 71
,, ,, with fumes enclosed, 27
,, ,, with peroxide of lead battery, 37
,, ,, working cost of, 299
Gun-discharge electrical, 45

Digitized by Google

Gunpowder ignited by hydro-electric spark, 125
,, ,, not electrical, 45
Gymnotus, 154
,, account of, 549
,, and torpedo, organs compared, 50
,, electric force of, 539
,, experiments with, suggested, 539

H.

Harbour fortification, electrical, 508
Heat, a state of vibration, 177
Heated air to collect electricity, 214
Heat from attraction of atoms, 189
,, in ratio of square of current, 182
,, pictures, 16
Horizontal intensity, magnetic, 210
Horse, experiments on, 496
Hyde Park, experiments in, 51. 191
Hydrate of peroxide of lead, 87
Hydracid salts typical of all salts, 382
Hydro-electricity, an appropriated term, 292
Hydro-electric machine, 65. 210. 212. 285
,, ,, ,, described, 122
,, ,, ,, electricity reversed, 289
,, ,, ,, improved, 552
,, ,, ,, small, 290
,, ,, ,, theory of, 453
Hydro-electric rheometer, 338
,, ,, telegraph, 472
Hydrogenated water electro-motive, 156
Hydrogen by electrolysis, 232. 443
,, eliminated from vapour, 122
,, reduces metal, 384

I.

Ice-pails for induction, 58. 66
Ignition of electrodes, 277. 334
,, of powder measured, 565
,, of wire, 420
Illumination, electric, cost of, 24
,, by electricity, 312. 516. 519
Immersed plates, 393
Imponderable agents exist, 247
Incandascence of mercury jet, 73
Inclination magnetic, 210
Induced currents in electrolysis, 34
,, ,, of the earth, 80
Induction, atmospheric, 432
,, Faraday on, 55
,, of space, 407
,, voltaic, 337
Inductive action, static, 541
,, charge of cloud, 67
Inductometer, differential, 385
Instantaneous currents measured, 565
Instantaneity of discharge, 564
,, of flash and noise, 404
Institution of civil engineers, 63
Insulating pillar, 214
Insulation, no perfect, 430
,, of telegraph wires, 64
,, of water battery, difficult, 465
Inverse currents, 490
Iodine, electro-negative, 209
Ions, grouping of, not altered by water, 529
Iron bar revolving, heat from, 187
,, coated by alkaline salt of copper, 367
,, ,, with zinc, 74
,, manufacture, with electr., 457
,, passive, 540
,, protected by oxide of lead, 90
Irritation of electro-motive nerves, 48
Isotropes, electrically, 344
Ivory jets, neutral to steam, 130

J.

Jets for hydro-electric machines, 61. 65

K.

Kensington Gardens, experiments in, 51
Kew Observatory, 213
King's College, experiments at, 542

L.

Latent heat, a mechanical power, 189
Law of voltaic force, 21
Lead, solution of, 256
Leaves covered with oxides, 90
Lectures on electr., Noad's, 228. 302
Less-resinous is vitreous, 412. 414
Leyden and torpedo shock not similar, 49
,, jars, fracture of, 281
Light inducing magnetism, 220
Lightning, 152. 154. 174
,, accident by, 309
,, averted from ships, 395
,, damage by, to ships, 301
,, double flash of, 551
,, effects of, 309
,, flashes at Strasburg, 167
,, ,, phenomena in, 562
,, its mechanical action, 562
,, its path pre-traced, 145
,, leaves material traces, 244
,, not attracted, 407
Lightning-rods, 142
,, ,, for ships, 396
,, ,, not attractors, 504
,, ,, not avertors, 504
,, ,, of Nelson column, 152
,, ,, of Royal Exchange, 233. 503
,, ,, of Strasburg, 167

Digitized by Google

Lightning-rods, protecting value of, 152
,, ,, size of, 504
Lightning, supposed forms of, 541
Lime-light, intensity of, 331
Limits of safety from lightning, 153
Lines of least resistance, 145
Liquids in the earth, reaction of, 580. 582. 585, 586
Loadstones improved, 389
Local attraction neutralized, 606
London Institution, 220, 294, 536, 601
Longitude determined by electro-telegraphy, 471. 611
Loss to the navy by lightning, 395
Luminous voltaic arcs, 333

M.

Macintosh-cloth, electr. of, 503
Magnetical investigations, 222
,, observations, 214
,, ,, reduced, 605
Magnetic force measured, 354. 355
,, ,, superficial, 597
,, ,, variations of, 210
Magnetic globe, 372. 377
,, instruments, catalogue of, 384
,, manipulation, 535
,, needle on ballistic pendulum, 566
,, note, 527. 555
,, ,, for telegraphy, 556
,, ,, illustrated, 601
,, ,, not from magnetic induction, 557
,, pictures, 150. 153
,, poles, Biot's, 571
,, ,, Gilbert's, 570
,, ,, Hansteen's, 571
,, tube, 378
,, vibrations, sonorous, 527
Magnetism, 373
,, by lightning, 562
,, coerced by lightning, 562
,, extraordinary, 394
,, generality of, 107
,, superficial, 353
Magnetization, 222. 610
,, non, by electric organ, 49
Magnetized steel-globe, 134
Magneto-electric battery, 232
,, ,, induction, 540
,, electricity and heat, 186
,, ,, for blasting, 234
,, ,, generated by electro-magnetic machine, 138
,, ,, heat from, 138. 178
,, electric spark, 540
,, ,, telegraph, 64
,, electro-plating, 313
,, ,, telluric battery, 81. 335
Magnet of Royal Society, 226
,, ,, separate molecules, 150
Magnets, accidents of, 136
,, in manufactories, 554
,, various, best steel for, 225
Manufactures, electr. of, 499
Massachusetts, declination and dip, 309
Material particles in electric light, 236
Matter and electr. inseparable, 244. 247
,, motion little understood, 221
,, epigram on, 309
,, is continuous, 297
,, nature of, 295. 536
,, pervades space, 298
,, transfer of, 315, 564
Matt, how to obtain, 97, 99, 560
Measuring short intervals, 565
Mechanical application of electr., 104
,, change in conducting wires, 528
,, value of heat, 138, 178, 187
Mercury cups, acorns for, 554
,, in electro-gilding, 98
,, jet incandescent, 73
Metallic cloth, 367
,, deposits not secondary actions, 384
,, salts, electrolysis of, 601
Metallo-chromes, Nobili's, 100. 251.
Metal not reduced by nascent hydrogen, 531
,, particles not cause of electric light, 274
Meteors of August, 553
Micrometer electrometer, 464
Minerals, formation of, 192
Mines, experiments in, 190
,, sprung by electr. 233
Mixed metals deposited, 393
,, nerves, how to detect, 493
Molecular hypothesis untenable, 383
Monobasic electrolytes, 534
Monochromatic plates, 267
More-resinous vapour, 414
Moser's images, 5. 82
Motive power of electr. 298
Mud-battery, 523
Murderer traced by electric telegraph, 604
Muscles, pile of, 545
Muscular contraction and current, 490
,, ,, its analogues, 46
,, ,, laws of, 490
,, ,, measurer, 498
,, ,, Swammeram's, 543
,, current, 71, 545
,, ,, in man, 604
Musical note from electro-magnet, 527. 555
Muslin cone for induction, 72

Digitized by Google

N.

Narcotics, their action on electric organ, 48
Nascent hydrogen, deoxidating, 197
,, ,, not reducing metal, 531
,, ,, reducing metal, 60
Native caloric, 245
,, electric currents, 576
,, voltaic pair, 190
Needles detected by electr. 606
Needle, direction of, in China, 509
,, for Œrsted's experiments, 385
Negative electric picture, 10. 12
Nelson column, lightning-rod of, 152
Nerves, action of electr. on, 46
,, mere conductors, 546
,, mixed, 490
,, ,, when contractile, 495
,, no electric currents in, 495
,, of motion, when contractile, 495
Nervous force measured, 497, 536
New Books, 229. 307, 386, 471, 550. 602
Nitrogen decomposed, 472
Nodal points for magnetic note, 527
Numerical value of electrc-motive force, 71

O

Ohm's law, 102
,, illustrated, 346
,, long unknown, 2
Oils modify electr. of steam, 63. 130
Omnia, 554. 614
One-metal, effects, 443
Opposite transfer of matter, 236
Ores, electro-treatment of 95
Oxide influences steam-electr. 128, 287
,, of zinc, its action, 193
Oxides applied to metals, 85
Oxygenated water, 195
,, not electro-motive, 156
Oxygen electrolytically obtained, 85
Oxy-hydrogen battery, 155
Oxy-phosphions, 530
Ozone and hydrogen form nitrogen, 384
,, by chemical means, 383,
,, its existence doubtful, 310
,, memoir on, 554

P.

Painting by electrolysis, 266
Palladium for lightning rods, 153
Palm-tree, electrical, 57
Paper-manufacture electrical, 459, 501, 503
Partridge-wood steam-jets, 124, 291
Patent laws at fault, 390
Pendulum, ballistic, 565
,, voltaic, 116
Penetrability of matter, 298
Peroxide of lead, oxhydrous, 88
Peroxide of lead battery, 28, 35, 36
,, ,, hydrate of, 87
,, ,, not good in series, 37
,, manganese battery, 36
Philosophical Magazine, 65
Phosphates, electrolysis of, 529
Phosphorescence by induction, 444
,, by polarized light, 447
,, by radiation, 446
,, by reflection, 447
,, not chemical, 448
Phosphorescent bodies, list of, 450
Phosphorogenic emanations, 444
Phosphorus, solution of, 535
,, solution with wax, 366
Photographic engraving, 611
Photometry, electrical, 272, 273. 325, 333
Physical science in England, 390
Physiological phenomena, 547
Pile of muscles, 545
,, without oxidable metals, 67
Pit-coal and coke to produce a carbon, 17
Plated goods, manufacture of, 217
Platinode defined, 270
Plating and gilding solutions, 388
Platinizing, 105
Platinode, Daniell's, 382.
Platinode defined, 529
Platinum point melted by lightning, 172
,, preferable to carbon, 22
,, superseded by carbon, 16
Plumbago, artificial, 70
,, improvement for, 231
Polarity of particles produce sound, 558
,, old recipe for, 610
Polarization, 607
,, maximum, 439
,, of dielectrics, 281
,, of electrodes, 392, 433, 486
,, of plantinum, 108, 159
Polar tension before contact, 380, 466
Polybasic electrolytes, 534
Polytechnic institution, hydro-electric machine for, 122
Ponderable matter augments electrical light, 274
,, cause of electrical light, 243
,, not cause of electrical light, 274
,, transfer of, 235
,, through solids, 236
Positive electrical picture, 10, 12
,, wire heated, 106
Potash solution of lead, 89
Potatoes grown by galvanism, 610
Practical magnetics, 222
Preparation of surfaces, 257
Prepared frogs treated with narcotics, 546
Pressure and separation, electrical, 461

Digitized by Google

Pressure influences electricity of steam, 129
Priestley's spots, 174, 389
Prime conductor made a rubber, 359
Priming influences electricity of steam, 128
Printing of meteorological observations, 212
,, telegraph, 140, 150
Projectiles, their velocity measured, 350, 390, 473, 569, 611
Proper current, 545
Psychrometer registered, 212
Pulverulent surface of electrodes, 34

R.

Radiation of currents, 489
Railway act and electric telegraphs, 553
Rain, greater, from resinous clouds, 415
Reaction, voltaic, 314
Reduced length defined, 202
Reflex action, 492
Reguline deposit, 59
Resinous clouds, 411
Resistance-coils, 204
,, defined, 201
,, measurer, 53
,, mode of measuring, 104
,, of battery and coil to be equal, 180
,, ,, its effects, 38
,, of liquids measured, 207
,, of long wires, 165
,, of the earth, nothing, 590. 592, 593. 596
,, path of least, 504
,, to electrolysis, 35. 59
Rheo-electric current, 292
,, ,, machine, 132. 292. 554
Rheo-meter, defined, 202
,, ,, hydro-electric, 338
,, ,, thermo-electric, 338
Rheo-motor defined, 202
Rheo-phore defined, 202
Rheo-scope defined, 202
Rheo-stat, 204. 385. 386. 203
Rheo-tome, 203
Roots, decayed, conductors, 580
Rotation, magnetism by, 598
Royal Institution, 55. 101. 295
,, Society, 129. 193. 380, 529
Rubbers against escaping steam, 130

S.

Sal-ammoniac for constant battery, 323
Salts classed all as one, 382
Seal-skin used as lightning protector, 143
Secondary compounds, electrolysis of, 381. 384. 529
,, current, 31. 488
Secondary current made available, 434
,, effects, interference of, 577. 581
,, pile, Ritter's, 433
,, polarities, 108
Serpentine river, experiments in, 51
Sheffield plate, hard silver, 218
Ships' bottoms, electro-coppered, 60
Ships protected from lightning, 395
Signal apparatus, 391
Silliman's Journal, 70. 74
Silvering liquor, 310
Simultaneous observations, 214
Single pair, chemical action of, 30
,, ,, gives static effects, 470
,, ,, its action increased, 76
,, prism of electric organ active, 49
Society of Arts, 64
Soirée, electrical, Mr. Gassiot's, 105
Solar images, 333
,, light, intensity of, 329
Space permeates matter, 296
,, vitreous or less resinous, 408. 412
Spark before contact, 380. 465
,, from induction of earth, 335
,, in vacuo explained, 244
Spiral for negative metal, 442
Spongy platinum, assimulation to, 34
Standard of resistance, 204
Static differ from dynamic effects, 465. 563
,, effects from one cell, 381
,, ,, precede dynamic, 381, 486
,, electricity, Faraday on, 101
,, induction, Faraday on, 67
Steam electrical from rapid separation, 453. 455
,, electricity of, 61. 101. 450. 540
,, globe, Faraday's, 61. 130
,, jets, 231
,, not superseded by electro-magnetism, 299
Steel for magnets, 222. 391
,, not producing magnetic note, 557
,, varieties of, for magnets, 136
Strata, the four great, described, 578
Street illumination by buried plates, 525
Subdivision inherent in matter, 245
Submarine battery, 507
Suboxide of hydrogen by catalysis, 158
Subterraneous batteries, 516. 526
Sugar for saturating graphite, 17
Sulphuret of antimony electrolyzed, 106
Sun, magnetic axes of the, 571
Superficial residence of charge, 57
Surface of tubes influences electr. of steam, 128
Swelling of fused conducting wire, 120

T.

Tangent-compass, 482

Digitized by Google

Tarnish of electro-plate prevented, 75
Telegraph by buried plates, 52
,, electric, 604
Telluric electro-motive force, 593
Temperature of subsoil measured, 390
Temper for magnetic steel, 223
Tenacity of magnetism, 222
Tension destroys magnetic-note, 558
Terrestrial currents, 570
,, ,, motions of, 575. 579
,, ,, none E. and W., 574
,, ,, tumultuous, 573
,, magnetism, 313. 371. 378
,, ,, its origin, 570
Test-magnet, 222
Thames, electro-telegraph across, 64
Thermo-electric current, 574
,, ,, pair, force of, 207
,, ,, rheometer, 338
,, electro-plating, 388
Thermometer registered by electr., 212
Thermoscope, 34
Thin films, 251
,, plates for magnets, 181
Thunder, 552
,, clouds, structure of, 57, 66
,, continuous, 551
,, storms, meteorology of, 470
,, nature of, 142
Time essential to polarization, 282
Time-telegraph, 103, 362
Tithonometer, 234
Torpedo and gymnotus compared, 50
,, diffusion of discharge, 548
,, experiments on, 46
,, nobiliana, 74
,, not expanded by discharge, 548
,, occidentalis, 232
,, researches on, 549
Tottering equilibrium, 504
Train of light with lightning-stroke, 403
Transfer of ions, 383, 384
,, of ponderable matter, 236. 334. 532. 585
Transport of particles in voltaic flame, 73
Transverse force of voltaic currents, 120
Tribasic salts electrolyzed, 529, 530
Tropical upper current resinous, 416. 419. 423
Two currents in one wire, 74
,, electricities, modifications of one, 246

U.

Uniform tints, 261
,, ,, of thin films, 100
Universal magnetism, 379

V.

Vacuum for electric light, 526
Vaccuo, electrolysis in, 31. 32
Vaporization and evaporation, 564
Vaporo-electric machine, 292
Vapour, when electrical, and when not, 409. 451. 455
Varnishes for coloured films, 267
Velocity, its effects, 244
,, of transferred matter, 244
Vibration of voltaic flame, 73
,, theory of, 596
Vicinal connections, 145, 506
,, ,, at Strasburg, 170
Violet of Mars, 92
Vitreous and resinous relative, 422
,, clouds, 410
,, is less resinous, 412
Voltaic action, new cases of, 67
,, arc, 599
,, ,, history of, 518
,, compared with lime-light, 332
,, ,, with solar light, 331
,, condenser, 38, 78.
,, ,, when useless, 40
,, constants, 201
,, element, Wheatstone's, 204
,, governor, 112
,, induction, 337
,, light, intensity of, 325, 329
,, pairs, natural, 190
,, phenomena, 118
,, pile and magnet, analogous, 132
,, ,, Bunsen's, 19, 23, 25
,, ,, De la Rive's, 28
,, ,, source of its power, 539
,, reaction, 314
,, ,, measured, 206
Voltameter, Faraday's, 33
,, Roberts's, 284

W.

Warner's secret, 507
Watch melted by lightning, 387
Water and saline solution, reactive, 581
,, and sulphur water, reactive, 585
,, battery experiments with, 380, 465
,, ,, long series of, 106
,, decomposed by one pair, 35, 78,
,, highly electro-positive, 130
,, its universal presence, 579
,, pipes for discharging train, 505
Waterspout, 612
Water when evaporated by electr., 564
Wet method of cleaning metals, 97
White metal gilded, 232
Whizzing noise of lightning, 403

Z.

Zincode, Daniell's, 382
,, defined, 529
Zones of cloud, 368

Digitized by Google

ERRATA.

Page 5, line 8, for *Reiss* read *Riess.*
— 5, — 19, for *Möser*, read *Moser*; et passim.
— 10, — 17 and 22, for *horneblende*, read *hornblend.*
— 11, — 41, for *drawing*, read *drawn.*
— 71, — 10 and 11, for 1817, read 1717.
— 154, — 36, for *positive*, read *polished.*
— 164, — 38, for *cut*, read *cup.*
— 166, — 34, for *equator*, read *equation.*
— 222, — 15, for *Alphinus's*, read *Æpinus's.*
— 228, — 36, for *Batto*, read *Botto.*
— 236, — 16, for *Muschenbrock*, read *Muschenbroek.*
— 237, — 23, for *Vecenza*, read *Venice.*
— 279, — 13, for *A.M.*, read *LL.B.*
— 293, — 30, for *P P*, read *r r.*
— 307, — 22, for *Duperré*, read *Duperrey.*
— 321, — 36, for *dento*, read *deuto.*
— 334, — 35, for *hole*, read *pole.*
— 357, — 30, for *dynanometer*, read *dynamometer.*
— 369, — 24, for *electromotor*, read *electrometer.*
— 378, — 14, for *course*, read *cause.*
— 450, — 8, for *hyposulphate*, read *hyposulphite.*
— 464, — last, for *electrometer*, read *electromotor.*
— 472, — 30, for *W. Highton*, read *H. Heighton.*
— 488, — 18, for *electrometers*, read *electromotors.*
— 501, — 10, for *copper*, read *copperas.*
— 529, — 2, should be *Royal Society.*
— 529, — 44, for *acic* read *acid.*
— 531, — 18, for *oxygen*, read *hydrogen.*
— 542, — 40, for *Miller*, read *Millar.*
— 548, — 13, for *give*, read *gives.*
— 549, — 44, for *Lekeby*, read *Letheby.*

Digitized by Google

London:
Printed by Stewart and Murray,
Old Bailey.

Digitized by Google

Digitized by Google

Digitized by Google

Digitized by Google

To avoid fine, this book should be returned on
or before the date last stamped below

Digitized by Google

Stanford University Libraries
3 6105 026 498 464

621.305
E3875
v.1
1845

Stanford University Library
Stanford, California

In order that others may use this book, please return it as soon as possible, but not later than the date due.

Digitized by Google